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INTRODUCTION.

As explained in this Introduction during 1914, the MONTHLY WEATHER REVIEW now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The MONTHLY WEATHER REVIEW contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports of climatological data for the respective States, Territories, and colonies.

Since December, 1914, the material for the MONTHLY WEATHER REVIEW has been prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology*.—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology*.—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere*.

SECTION 4.—*Rivers and floods*.

SECTION 5.—*Seismology*.—Results of observations by Weather Bureau observers and others as reported to the Washington office. Occasional original papers by prominent students of seismological phenomena.

SECTION 6.—*Bibliography*.—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 7.—*Weather of the month*.—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation; data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto.

In general, appropriate officials prepare the seven sections above enumerated; but all students of atmospherics are cordially invited to contribute such additional articles as seem to be of value.

The voluminous tables of data and text relative to local climatological conditions that, during recent years, were prepared by the 12 respective "district editors," are omitted from the MONTHLY WEATHER REVIEW, but collected and published by States at selected section centers.

The data needed in Section 7 can only be collected and prepared several weeks after the close of the month whose name appears on the title-page; hence the REVIEW as a whole can only issue from the press within about eight weeks from the end of that month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are especially due to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.
The Central Meteorological and Magnetic Observatory of Mexico.
The Director General of Mexican Telegraphs.
The Meteorological Service of Cuba.
The Meteorological Observatory of Belen College, Habana.
The Government Meteorological Office of Jamaica.
The Meteorological Service of the Azores.
The Meteorological Office, London.
The Danish Meteorological Institute.
The Physical Central Observatory, Petrograd.
The Philippine Weather Bureau.
The General Superintendent United States Life-Saving Service.

SECTION I.—AEROLOGY.

SECTION II.—GENERAL METEOROLOGY.

THE SNOWFALL OF THE EASTERN UNITED STATES.[1]

By CHARLES FRANKLIN BROOKS.

[Dated: U. S. Bureau of Plant Industry, Washington, Dec. 15, 1914.]

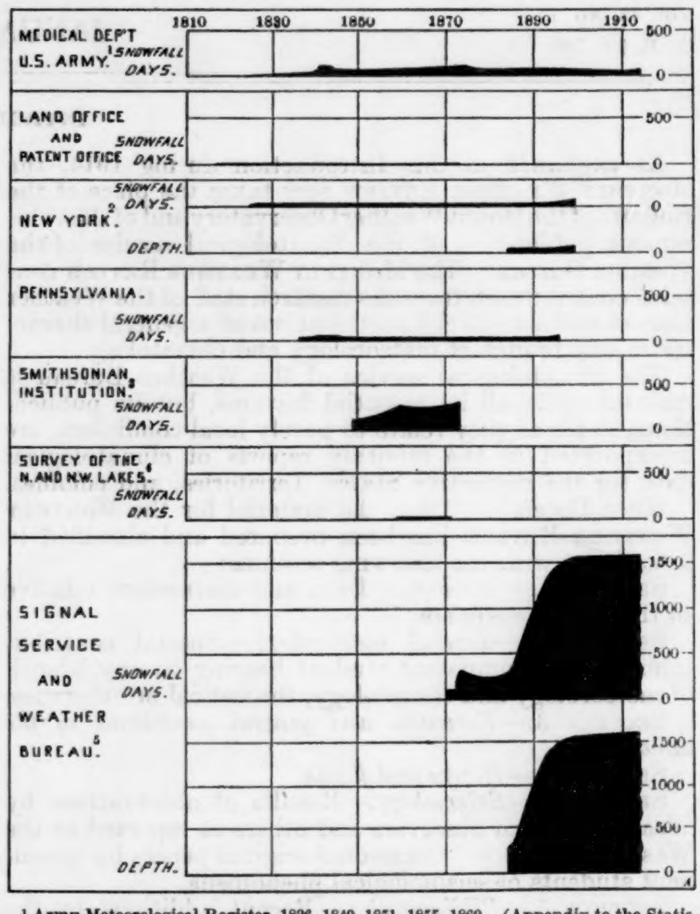
INTRODUCTION.

SNOWFALL OBSERVATIONS.

The earliest observations of snowfall in the United States were made by independent observers. These records are to be found in their original journals and scattered through newspapers, almanacs, books on climate, storms, or travels. Great snowstorms have always received attention. Sidney Perley has collected the reports of many such in his "Historic Storms of New England" (Salem, 1891), the delight of the advocate of the "old-fashioned snowstorm" (1).

As regards more or less continuous records, some observers have merely recorded the days on which snow occurred; others have, in addition, from time to time mentioned the approximate depth of snowfall and snow water, and still others have made complete snowfall observations. The manuscript Meteorological Journal of Gov. William Plummer, Epping, N. H., 1796 to 1834, in the library of Blue Hill Observatory, not only contains full snowfall records day by day, but also has them neatly summarized for the whole period (2). The American Almanac from 1834 to 1861 published the results of meteorological observations at several places, many of the series containing snowfall records. Blodget has summarized some of these and others; they are given in his "Climatology of the United States" (see p. 3).

Organized meteorological observations, including snowfall days, began in 1814, when the Army post surgeons were ordered to keep weather diaries. However, few returns are to be had for the ensuing five years. In 1817 Josiah Meigs, Commissioner of the General Land Office, started meteorological observations at the 20 land offices in the eastern United States. Observations of snowfall days and snowstorms were included. In 1819 Surg. Gen. Lovell organized meteorological observations in the United States Army on a firm basis. In 1825 the New York Legislature established the "New York University system" of meteorological observations. Snowfall days were regularly recorded and depth of snowfall received some attention. In 1836 Pennsylvania began a State weather service, the reports going to Prof. J. P. Espy, of the Franklin Institute (3). In 1840 J. P. Espy, on taking charge of the Army meteorological observations, succeeded in procuring the services of more than 100 voluntary observers. He, with Loomis and Redfield, encouraged Joseph Henry, then Secretary of the Smithsonian Institution, in the establishment of a weather service national in scope. Such a service went into operation in 1849. The Patent Office observers (outgrowth of Meigs's system), the observers of the State services, and many other voluntary observers sent meteorological reports as a part of the Smithsonian system. Melted snowfall was recorded as distinct from rain (4). From 1859 to 1871 the Survey of the Northern and Northwestern Lakes, under the Engineer Corps of the United States Army, observed snowfall days among other meteorological phenomena.



[1] Army Meteorological Register, 1826, 1840, 1851, 1855, 1860. (Appendix to the Statistical Report on the Sickness and Mortality in the Army of the United States from 1855-1860, by R. H. Coolidge.)

[2] Regularly published in the annual reports of the Regents of the University of the State of New York, 1825-1849, and for a few stations later. See also F. B. Hough, New York Meteorology, 1826-1850, and 1851-1863.

[3] Original manuscripts in the archives of the Weather Bureau.

[4] Annual Report on the Survey of the Northern and Northwestern Lakes for the year ending June 30, 1867, by W. F. Raynolds, Appendix U, Report of Secretary of War, 2d sess., 40th Cong.; vol. 2, 1867-68.

[5] See figure 2 below.

FIG. 1.—Graphic representation of the history of organized snowfall observations in the eastern United States. (Right-hand scale indicates number of stations reporting.)

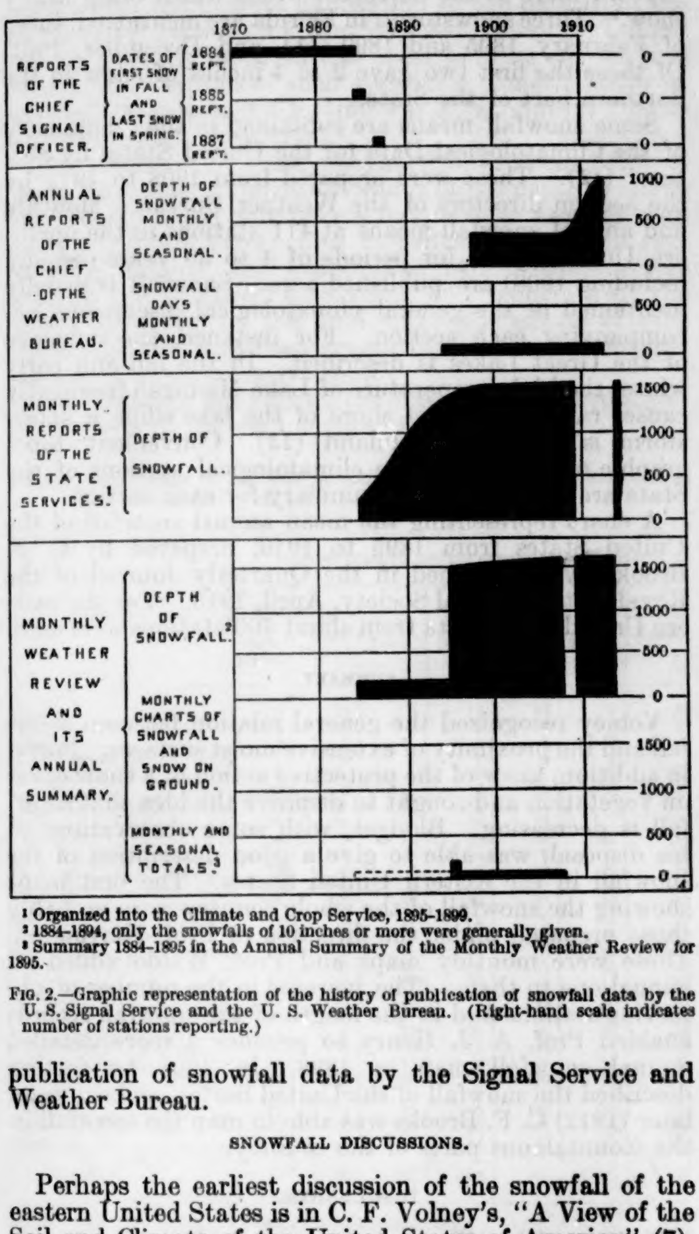
In 1870 Congress authorized the meteorological division of the Signal Service. In 1873 this new bureau took over the preceding records from the Army surgeons, and in the same year the Smithsonian Institution transferred its meteorological work to the Signal Service. Extensive observations of the depth of snowfall for each 24 hours began in the spring of 1884. "The number of inches and tenths of inches of snow which fell during the 24 hours was determined as accurately as possible by

[1] This work is the revised major portion of a thesis submitted as part of the requirements for the degree of doctor of philosophy in meteorology at Harvard University. It was prepared from June, 1913, to May, 1914, under the supervision of Prof. Robert DeC. Ward.

The section on "The Distribution of Snowfall in Cyclones of the Eastern United States" was published in the MONTHLY WEATHER REVIEW, June, 1914, 42: 318-330.—*The Author.*

measurements made at points where the snow appeared to be of average depth" (5). In 1891 the meteorological work of the Army Signal Service was transferred to the Department of Agriculture and the present Weather Bureau was organized (6).

Figure 1 represents graphically the history of organized snowfall observations in the United States east of the Mississippi River, and figure 2 shows the history of the publication of snowfall data by the Signal Service and Weather Bureau.



[1] Organized into the Climate and Crop Service, 1895-1899.
[2] 1884-1894, only the snowfalls of 10 inches or more were generally given.
[3] Summary 1884-1895 in the Annual Summary of the Monthly Weather Review for 1895.

FIG. 2.—Graphic representation of the history of publication of snowfall data by the U. S. Signal Service and the U. S. Weather Bureau. (Right-hand scale indicates number of stations reporting.)

SNOWFALL DISCUSSIONS.

Perhaps the earliest discussion of the snowfall of the eastern United States is in C. F. Volney's, "A View of the Soil and Climate of the United States of America" (7). From 1795 to 1798 Volney was traveling in this country, and during that time gathered the information presented. The heavy snowfall of northern New England and eastern Canada is mentioned in marked contrast to the snowfall of equal latitudes in Europe. Southward the snowfall decreases rapidly. Virginia is described as practically the southern limit of sleighing; the distribution of sleighs seen in barnyards indicates this. In the Appalachians the snow goes much farther south.

Two extraordinary snowstorms are mentioned: At Norfolk, Volney says that 5 feet of snow fell on February 4, 1798, and 40 inches more with a northeast wind during the night February 14. Most of the snow in the eastern United States is said to come with northeast winds. The influence of available moisture as a considerable factor in snowfall was recognized; Volney says that Quebec has more snow than Montreal because it is not so far from the Atlantic. The Ohio Valley and the lee shores of the Great Lakes have wet northwest winds in winter because of the moist surfaces traversed.

Dr. Samuel Forry in his "Climate of the United States and its Endemic Influences" (New York, 1842), and "Meteorology" (New World, New York, April, 1843), touches on snowfall in a general way. He mentions the well-known protection which a snow cover, as a poor conductor of heat, affords vegetation. In discussing alleged changes of climate in this country two of his quotations relate to snowfall. He quotes Richard Sexton as follows:

> But there will doubtless be an amelioration in this particular [climate] when Canada and the United States shall become thickly peopled and generally cultivated. In this latitude then like the same parallels in Europe at present, snow and ice will become rare phenomena. * * *

He also quotes from Thomas Jefferson's Notes on Virginia:

> Snows are less frequent and less deep; they do not lie below the mountains more than one, two, or three days and very rarely a week. They are remembered to have been formerly frequent, deep, and of long continuance. The elderly inform me that the earth used to be covered with snow about three months in every year.

Such statements Forry justly claims are disproved by records.

Lorin Blodget devoted two pages to snowfall in his voluminous "Climatology of the United States" (8). He uses data gleaned principally from the American Almanac, and the Army's and States' observations. He mentions the usual transiency of snow south of the Great Lakes as compared with the 2 feet or more of snow which stays on the ground for several months in northern New England, northern New York, and eastern Canada. Blodget remarks on the great variation of snowfall from year to year. In New York there are prodigious amounts sometimes; in the winter of 1855-56, in one storm 3 to 5 feet of snow fell on the plain of western and central New York, and still more in the mountains east and south. Other winters may pass with relatively little snowfall. Westward the snowfall generally decreases. However, in the vicinity of Lake Superior the snowfall is heavy, but less than the extremes of New York.

> Below or south of the 41st parallel the snows are extremely irregular and yet often profuse and excessive. They are more likely to occur in February and the spring months as extraordinary phenomena than in the early part of the winter, and instances are frequent of profuse April snows. A few citations of the observed average depths of snow may be given here [Table 1], taken from various published notices mainly (p. 345).

TABLE 1.—*Observed average depths of snowfall at various periods and from various sources.*

Sources.	Blodget's table. 1		During next 50 years. 2		Difference.
Locality.	Record.	Depth.	Record.	Depth.	1—2
	Years.	*Inches.*	*Years.*	*Inches.*	*Inches.*
Oxford County, Me.	12	90	14	85	+ 5
Dover, N. H.	10	68.6	....	....	....
Montreal, Canada	10	67	15	125.7	−58.7
Burlington, Vt.	10	85	18	61	+24
Worcester, Mass.	12	55	18	51	+ 4
Do.[1]	21	53.5	....	....	2.5
Amherst, Mass.	7	54	18	46	+ 8
Hartford, Conn.	24	43	18	45	− 2
Lambertville, N. J.	8	25.5	17	34.5	− 9
Cincinnati (Dr. Ray)	16	19	18	19	0
Burlington, Iowa	4	15.5	....	....	....
Beloit, Wis.	3	25	17	31	− 6

[1] National Almanac for 1863.

Surely from the rough comparison of present-day records with those of 50 years earlier no widespread change of snowfall is indicated.

Probably the first set of maps representing the snowfall of the United States was published under the direction of Prof. Mark W. Harrington in 1894, then chief of the Weather Bureau (9). There are eight charts showing the snowfall for each month from October to May. Owing to the limited number of stations, particularly in the mountains, the distribution of snowfall could be shown in a general way only. The size of the individual charts, $7 \times 4\frac{1}{2}$ inches, gives a good indication as to the detail. Lines of equal snowfall are drawn for 0, 1, 3, 5, 10, 15, and 20 inches. The period used is from 5 to 20 years, most of the records being not over 7 years long (1884–1891).

The main features of the charts are the snowfalls in excess of 20 inches in the winter months in the Upper Lake region and northern New England. The January chart shows snowfall south to central Florida. In the very brief discussion accompanying these charts Prof. Harrington lays most emphasis on mountain snowfall.

In Prof. Frank Waldo's "Elementary Meteorology" (New York, 1896), a chart of the mean annual snowfall of the United States is given (1884–1891). The heaviest snowfall indicated is in the Lake Superior region. In the text, Prof. Waldo says that at low altitudes in the country as a whole snow seldom lies on the ground south of the 31st parallel nor south of the 33d on the coast of the South Atlantic States.

Prof. A. J. Henry, in the MONTHLY WEATHER REVIEW for March, 1898, published mean annual snowfall data for 159 regular Weather Bureau stations throughout the United States, and for 24 Canadian ones. The lengths of the periods vary between 3 and 11 years. These data are shown on a map by lines representing 0, 1, 5, 10, 20, 30, 50, and 100 inches of snowfall. Even with so few stations, the heavier snowfall on the east, than on the west shores of the Great Lakes, is indicated. The Appalachians have heavier snowfall than the plains east or west. The 0 line does not include all of Texas and but little of Florida.

In 1906 the Weather Bureau published a large work entitled "Climatology of the United States" as Bulletin Q of the Weather Bureau (10). For the United States east of the Mississippi the data presented are from 358 stations. Including the year 1903, most of the records are less than 15 years in length. In the general discussion the positions of the 5-, 50-, and 100-inch lines of equal annual snowfall are described. They correspond roughly to those on the chart presented below. In the voluminous tables which comprise most of the book (900 pages), the average depth of snowfall is given for each month, for each of the four seasons, and for the year. Also the greatest depth in 24 hours is given for each month. The data are arranged by States. At the beginning of the tables for each State is a general discussion of the topographic features, temperature, and precipitation. The details of snowfall distribution are mentioned, even to the extent of describing some severe snowstorms, particularly in the southern States. In connection with the maximum snowfall in 24 consecutive hours, the storm of March, 1888, is said to have set the record for the northeastern States, and the severe snowstorms of February, 1895, and February, 1899, for the southern States. In the discussion of the snowfall of Wisconsin the apparently greater snowfall in the northern and southern parts of the State, as compared with the middle, is ascribed to the relatively greater distance of the middle from cyclone tracks on the north and south in winter. The heavy snowfall of upper Michigan and western Ontario is attributed to the influence of the Lakes, which is felt on the south and east shores because the wind is prevailingly northwest in winter. Concerning South Carolina it is stated that, although the average snowfall is heaviest in the high western part of the State, the greatest 24-hour snowfalls occur in the center. This part is exposed more to the northeast winds which bring heavy snow.[3] Three snowstorms in Florida are mentioned, those of February, 1895 and 1899 (11), and December, 1901. Of these the first two gave 2 to 4 inches of snow in the northern part of the State.

Some snowfall means are contained in the "Summary of the Climatological Data for the United States by Section" (12). These were prepared from 1908 to 1912 by the section directors of the Weather Bureau. Monthly and annual snowfall means at 411 stations in the northern United States for periods of 4 to 39 years (usually including 1908) are published here. Snowfall is usually mentioned in the general climatological discussions accompanying each section. For instance, the influence of the Great Lakes is described. In the fall and early winter the high temperature of Lake Michigan frequently causes rain on the west shore of the lake while a snowstorm is in progress inland (13). Convenient topographic maps showing the climatological stations of the State are included in the summary for each section.

A chart representing the mean annual snowfall of the United States from 1895 to 1910, prepared by C. F. Brooks, was published in the Quarterly Journal of the Royal Meteorological Society, April, 1913. For the eastern United States data from about 700 stations were used.

SUMMARY.

Volney recognized the general relation between snowfall and the proximity of extensive moist surfaces. Forry, in addition, knew of the protective action of a snow cover on vegetation and sought to disprove the idea that snowfall is decreasing. Blodget, with some observations at his disposal, was able to give a good description of the snowfall in the eastern United States. The first maps showing the snowfall of the whole country were probably those prepared under the direction of Prof. Harrington. These were monthly maps and Prof. Waldo added an annual one to them. The increase in the number of observing stations and in the length of the snowfall records enabled Prof. A. J. Henry to produce a more detailed annual snowfall map in 1898. In 1906 he further described the snowfall of the United States, and six years later (1912) C. F. Brooks was able to map the snowfall in the mountainous parts of the country.

DISCUSSION.

Today, with still more data available, an extensive study of the snowfall of the United States is possible. As a first step, the snowfall of the eastern United States is here charted (charts C.F.B. 1–15) and discussed. The order of treatment of this subject will be: (1) extent and accuracy of data used; (2) discussion of the distribution of snowfall and the factors involved. The charts presented include: *a.* average monthly snowfall, September to May; *b.* average annual snowfall; *c.* average directions of snow-bearing winds, December, January,

[3] The snowstorm of Feb. 25–26, 1914, may be cited as an illustration of this. One foot of snow fell in the central region of South Carolina and Georgia, but less in the west and south. This snow was practically gone within a week. Prof. Henry states that this is usually true for the South Atlantic and Gulf States. Snow is considered a burden, for it is soon converted into slush.

February, and March; *d.* average annual number of days with 0.1 inch or more snowfall; *e.* special charts and diagrams illustrating the snowfall about the Great Lakes.

DATA.

All available published snowfall data for the stations east of the Mississippi River from July, 1895, to June, 1913, were tabulated by months (see fig. 2). This period begins with the general publication of the data from the cooperative stations of the Weather Bureau. Longer records were not used, since in order to bring out the true geographic relations of such a variable climatic factor as snowfall, homogeneity in time—i. e., a uniform fundamental period—is essential.[3]

The accuracy of these published data is doubtful in many instances. The observations of the depth of snowfall, usually made only once a day or once a snowstorm, contain serious errors due to drifting, wind and rain packing, melting, and evaporation(**14**). Further errors arise in the printing, tabulation, and reduction of the data. However, on the final maps, the effects of such errors seem to have been practically eliminated through the use of such extensive data.

The following table shows the extent of published snowfall records of different lengths for each State:

TABLE 2.—*Number of stations furnishing snowfall data for the United States east of the Mississippi River, 1895–1913.*

State.	Number stations having snowfall record for—						
	18 years complete.	18 years in part.	14–17 years.	10–13 years.	6–9 years.	1–5 years.	Total.
Alabama	16	10	8	14	18	29	95
Connecticut	5	2	6	5	2	8	28
Delaware	0	2	1	2	1	2	8
District of Columbia	1	0	0	1	0	0	2
Florida	5	...	...	36	...	42	83
Georgia	20	8	16	17	20	36	117
Indiana	16	11	14	13	15	37	106
Illinois	21	16	25	23	19	71	175
Kentucky	9	9	12	10	10	31	81
Maine	4	3	4	6	8	22	47
Maryland	13	4	8	9	16	29	79
Massachusetts	8	5	8	14	11	47	93
Michigan	15	19	38	32	33	50	187
Minnesota [1]	4	3	1	2	6	1	17
Mississippi	27	2	9	11	15	46	110
New Hampshire	5	5	1	4	3	20	38
New Jersey	8	10	17	12	19	29	95
New York	15	10	40	30	42	112	249
North Carolina	12	12	10	18	22	55	129
Ohio	30	26	27	13	36	81	213
Pennsylvania	14	7	21	26	39	48	155
Rhode Island	4	1	0	1	1	1	8
South Carolina	24	1	14	8	4	23	74
Tennessee	18	5	23	11	16	39	112
Vermont	3	3	3	3	4	15	31
Virginia	11	4	15	7	23	55	115
West Virginia	4	11	16	20	11	45	107
Wisconsin	13	17	14	15	15	69	143
Total	325	206	351	363	409	1,043	2,697

[1] East of the Mississippi only.

The data were reduced with the aid of an adding machine. The monthly and annual averages obtained were first plotted on large scratch maps of the individual States and the lines of equal snowfall were then drawn. On the monthly charts lines for 0, 1, 2, 5, 10, 15, 20, 30, and 40 inches were used, and on the annual, those of 0, 1, 2, 5, 10, 20, 30, 50, 70, 100, and 130 inches. In drawing these lines I used only the means based on records for the entire 18 years, except where stations with such records were too far apart. For most States, the records 14 to 17 years long sufficed to fill in the gaps. But in the sparsely populated regions of Minnesota, Wisconsin, and Michigan and in the Appalachian region, still shorter records were used. However, none less than six years long was considered. So in these regions, at least, the charts are far from satisfactory as accurate representations of the true snowfall. In the Southern States, and everywhere for the fall and spring months, all records showing any snowfall at all were used in determining the position of the zero line.

[3] *See* MONTHLY WEATHER REVIEW, Washington, April 1902, 30: 205–243.

These charts represent the average monthly and annual snowfall from 1895 to 1913 only. With a longer period, many of the "islands" and some peculiar loops in the lines would probably disappear. This would apply particularly to the snowfall of the southern States, since there the average amounts are calculated from but few snowstorms.

The data for the charts of snow-bearing winds for the months December, January, February, and March were procured from the U. S. Daily Weather Maps (Washington) for these months for the 18 years from 1895 to 1913. The principle on which the wind roses were made is roughly the same as that employed on the monthly pilot charts of the U. S. Hydrographic Office. For instance, take the wind rose for Boston in December (chart C.F.B. 4). In the 18 years there were 31 occurrences of snow at 8 a. m. These were distributed as follows:

Wind direction.	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm.
Occurrences	16	3	2	1	1	1	0	7	0
Per cent of total	52	10	6	3	3	3	0	23	0

On the original map the length of the north arrow was drawn 0.52 of an inch long; that of the northeast arrow, 0.10 inch long, and so on. To take an extreme case, Vicksburg had but two occurrences of snow, one with a north wind and the other with a west wind. Thus there were but two arrows, each 0.50 inch long. The percentage of occurrences with no wind is indicated by a figure in the center, absence of any figure meaning 0.

THE AVERAGE DISTRIBUTION OF SNOWFALL.

The average distribution of snowfall in the eastern United States is much the same as that produced by a single cyclone. Northern regions well exposed to winds blowing from moist surfaces receive the heaviest snowfall. Thus the country about the Great Lakes and the North Atlantic States gets heavy winter snows. Farther south, although there is plenty of moisture, the temperatures accompanying precipitation in winter are not so favorable to snowstorms.

The Great Lakes region, the Atlantic Coast States, the Appalachians, the Gulf States, and the central valleys have distinct snowfall characteristics. Each region will now be considered separately.

The snowfall about the Great Lakes.

Perhaps the most striking feature of the early snowfall charts of the United States was the heavy snowfall indicated in the Lake region. Now, with a large number of stations and a comparatively long series of observations, the details can be studied.

For this purpose, the accompanying supplementary charts and diagrams (figs. 3–10) have been drawn. Figure 3 indicates the mean annual snowfall about the Great Lakes from 1895 to 1910. The data from about 100 stations were used, many records being incomplete.

In the region north and east of Lake Superior there are but three stations; so there, at least, the chart is only approximate. A longer series of years would have been used had there been more stations prior to 1895 or had the Canadian snowfall data after 1909 been published. Nevertheless, the general snowfall about the Great Lakes is indicated with some degree of accuracy. In general, it is to be seen that the snowfall is heavier in the north than in the south, and much heavier on the east shores

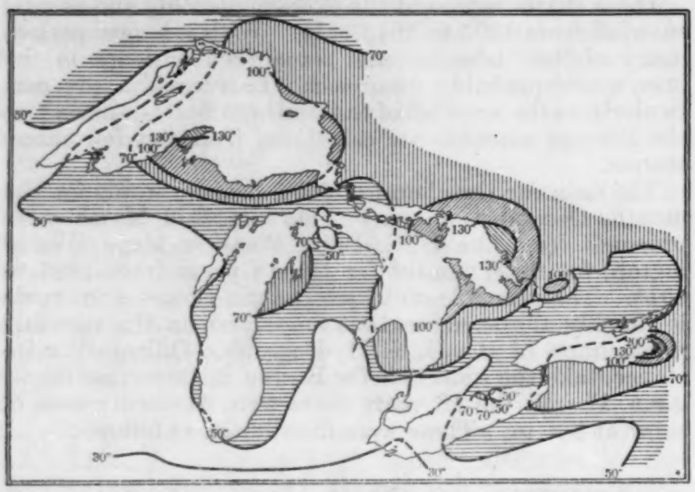


FIG. 3.—Average annual snowfall about the Great Lakes, 1895-1910 (100 stations). (Mercator projection.)

than on the west. For instance, Port Arthur has 31 inches and White River 93, Duluth 49, Calumet 136, Chicago 36, South Bend 63, Sandusky 29, Buffalo 78, Toronto 51, Adams 200.

Figure 4, representing the minimum annual snowfall for any year 1895–1910, looks much like the mean annual chart with some exceptions. For instance, the minima at Calumet and Adams are about the same; also Port Arthur and White River have equal minima.

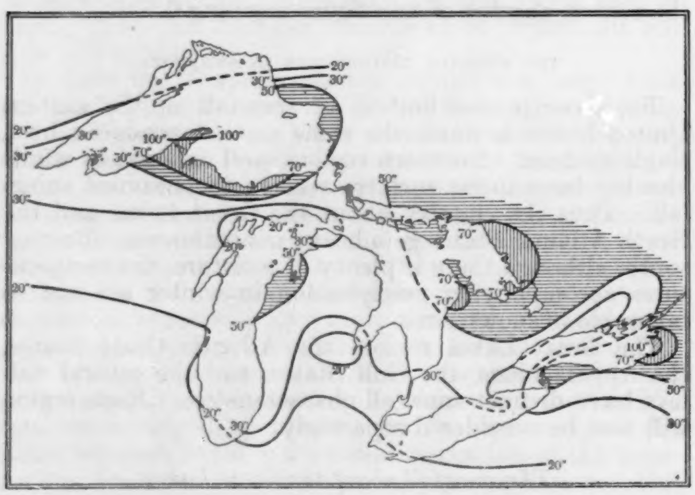


FIG. 4.—Minimum annual snowfall about the Great Lakes, 1895-1910. (Mercator.)

Figure 5, the maximum annual snowfall for the same period, also shows close resemblance to the annual snowfall distribution. The absolute maximum of 334 inches occurring at Adams is far in excess of that measured elsewhere in this region.

Figure 6 shows the difference between these maxima and minima. The most striking range is that of 134 inches at White River. This is nearly twice that at Calumet, where the mean annual snowfall is much greater. The large range of 229 inches at Adams is of little consequence, for the minimum is above 100.

The four diagrams represent monthly snowfall in inches and in per cents of the mean annual for different regions on the Lakes. Figures 7 and 9 are for the northern Lake region, west and east shores, respectively, and figures 8 and 10 for the southern Lake region, west and east shores. In figure 7, for the western shores of the northern Lake region, the five stations—Port Arthur, Ontario; Du-

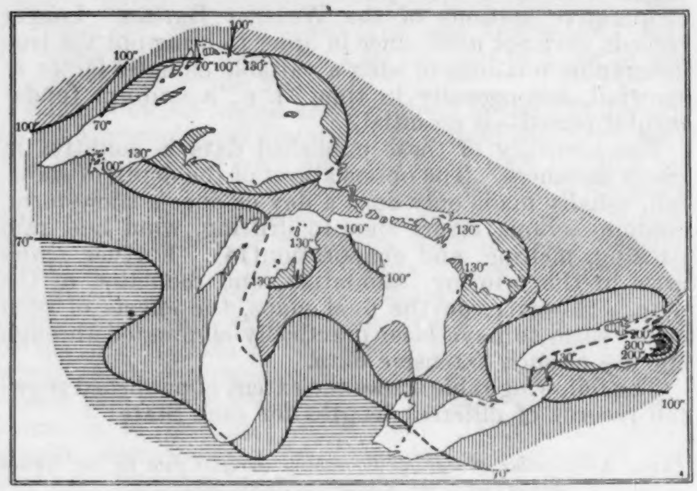


FIG. 5.—Maximum annual snowfall about the Great Lakes, 1895-1910. (Mercator.)

luth, Minn.; Escanaba, Alpena, and Cheboygan, Mich.—have been used. The mean annual snowfall (1895–1913) for these five was 49 inches. There is one column for the snowfall of each month from September to May. The scale on the left is in inches of snowfall for the middle part of each column and the per cent of the annual mean for the edges. The snowfall is fairly evenly distributed through the winter months, but with a slight minimum in January and a maximum in February.

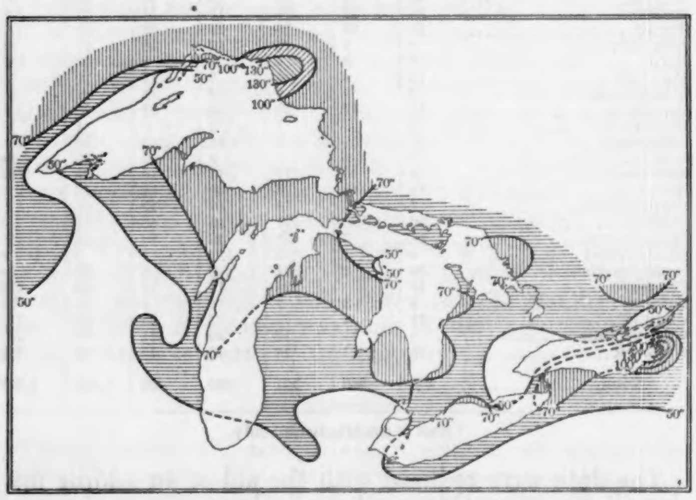


FIG. 6.—Extreme range of annual snowfall about the Great Lakes, 1895-1910 (fig. 5 minus fig. 4). (Mercator.)

Figure 8, for the west shores of the southern Lake region, is based on observations at Milwaukee, Wis.; Chicago, Ill.; Detroit and Port Huron, Mich.; Toledo, Ohio; and Toronto, Ontario. There is a slow rise to a late winter maximum in February followed by a rapid decline. The annual mean for the stations is 45 inches.

Figure 9, for the east shores of the northern Lake region, was made from observations at Calumet, Sault Ste. Marie, and Charlevoix, Mich.; Saugeen (Southampton)

and Parry Sound, Ontario. The annual mean is 103 inches—a sharp contrast to that of the west shores. The snowfall at these stations comes rapidly to a maximum in December and then slowly decreases.

Figure 10, representing the snowfall of the east shores of the southern Lake region, is based on observations

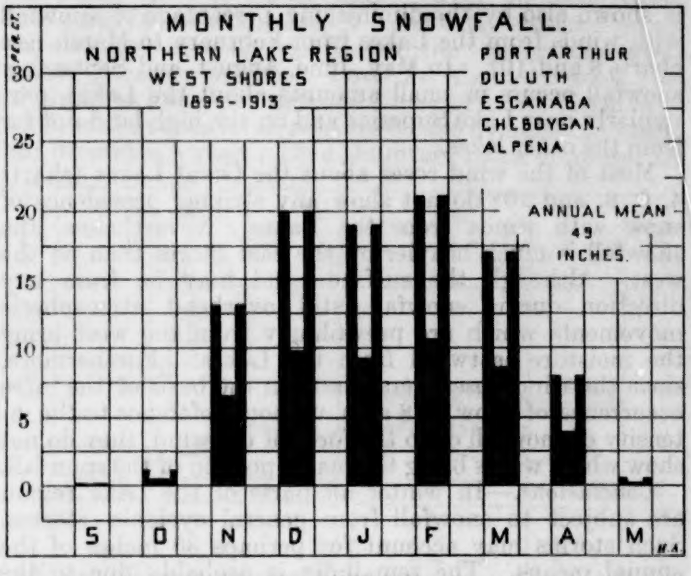


FIG. 7.—Percentage monthly snowfall for the western shores of the northern Great Lakes. (Mercator.)

from Cleveland, Ohio; Erie, Pa.; Buffalo, Oswego, and Adams, N. Y. The annual mean is 81 inches and the maximum comes in January.

The snowfall in the Lake region is derived from the abundant moisture precipitated at low temperatures by the frequent winter cyclones. The prevailing northwest winds and the relative nearness to the Atlantic and the

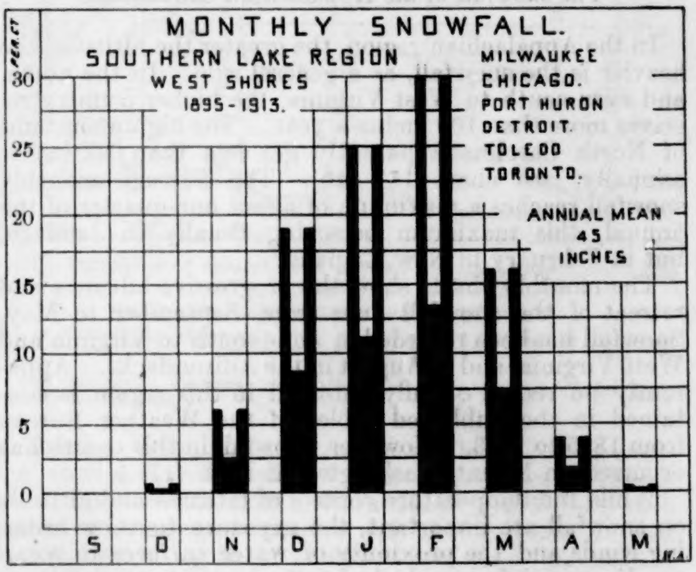


FIG. 8.—Percentage monthly snowfall for the western shores of the southern Great Lakes. (Mercator.)

Gulf of Mexico combine to make the eastern and southern Lake region more moist than the western and northern. In consequence there is generally diminishing winter precipitation northwestward, with local maxima on the leeward shores of the Lakes. The same would be true of snowfall if all the precipitation were in the form of snow.

In the south, however, the temperature during precipitation in winter is frequently too high for snow. So, although the maximum precipitation occurs in the southeast, the maximum snowfall is in the east and northeast. However, in the colder winters the snowfall in the south becomes heavier than in the north because more of the

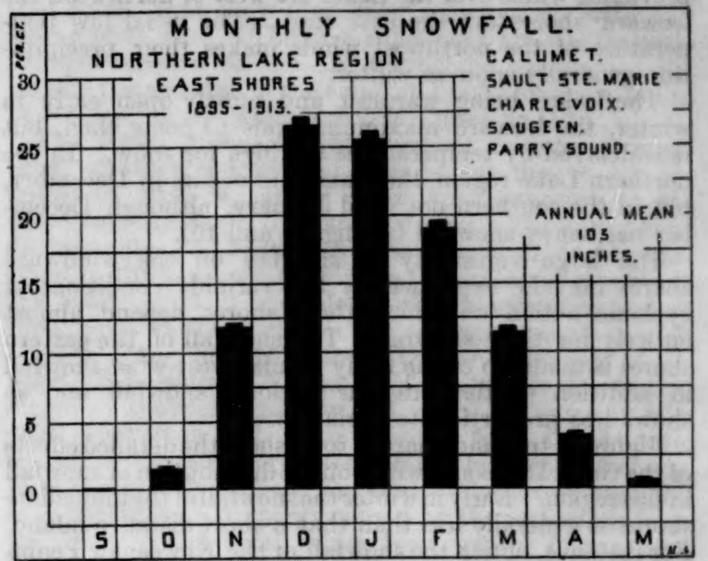


FIG. 9.—Percentage monthly snowfall for the eastern shores of the northern Great Lakes. (Mercator.)

normally greater precipitation occurs as snow. The deficiency of northern snowfall relative to southern in such cold periods is further accentuated by a decrease in the amount of snowfall in the north. This is due to the reduced moisture capacity of the colder air and to lack of normal cyclonic activity. The distribution of snowfall by months, as indicated in figures 7 to 10, shows this difference in the effect of lower temperatures on snowfall.

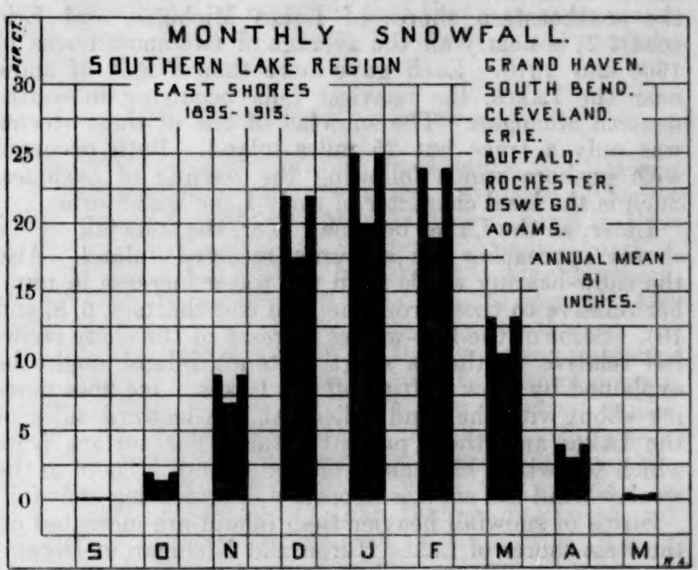


FIG. 10.—Percentage monthly snowfall for the eastern shores of the southern Great Lakes. (Mercator.)

Thus figures 7 and 9 for the north indicate the snowfall maxima in months which are not the coldest, while figures 8 and 10 for the south show the heaviest snowfall in the coldest winter months.

As was indicated in the discussion of the distribution of snowfall in cyclones (11), moist cyclone winds in winter

cause increased precipitation when blowing from a comparatively warm water surface over cold land. The cooling which produces this precipitation is caused partly by mixture and radiation but chiefly by forced ascent of the wind, due to increased friction and to topography. The result is heavy snowfall on leeward shores; since the prevailing winds over the Lakes are west or northwest, the leeward shores are the east ones. The usual low temperature of the northwest winds makes their precipitation generally snow in winter.

The Lakes being warmest and mostly open early in winter, the leeward maximum tends to come then, but it is delayed by temperatures too high for snow. In the northern Lake region, the maximum occurs in December, but in the southern not until January, although December has heavy snowfall (see figs. 9 and 10).

The large variability of snowfall on the windward shores may be explained by the variable conditions of cyclonic action on which these shores depend almost entirely for their snowfall. The snowfall of the eastern shores is made up of the fairly regular west-wind snowfall in addition to the irregular cyclonic snowfall and so shows less proportionate variation.

Figures 3 to 6 and charts 1 to 15 show the detailed effects of the Great Lakes and winds on the distribution of snowfall in this region. Early in winter the snowfall of the immediate shores is generally less than that a short distance inland. For instance, notice the snowfall of the Keweenaw Peninsula. Early in winter the snowfall on the Lake shore is but little more than half as great as that 1,000 feet higher; late in winter, the snowfall of the shore equals that of the higher land. A case in which distance from the warm water made heavy snowfall possible is that of the night of November 2, 1911. An "unprecedented fall of 18 inches (of snow) occurred at South Bend, Ind., although there was but little or none at any of the surrounding stations on that date" (15). On the other hand, snowstorms are sometimes confined to the very shores of the Lakes. The October snowfall indicated on the southeastern shores of Lakes Michigan and Erie (chart 2) is nearly all the average of two snowstorms in 1906 and 1910. Each gave more than a foot of snow near the Lakes, the heaviest falls occurring in southwestern Michigan. The snowfall of one of these storms was only a trace but 25 miles inland. Both occurred with onshore winds following the passing of cyclones. Such is the local character of early Lake snowstorms.

Later, as the Lakes become cooler, the snowfall on the shores approaches the amounts received inland. Also the snow-bearing winds from the water increase in number relative to those from the land (see charts 4, 6, 8, and 10). Some of the late-winter increase of the shore snowfall relative to that a short distance inland might be explained by snow drifting off the Lakes. Ice floes moving about with the wind collect at the leeward sides of the Lakes and there present a fairly flat surface from which the winds blow snow onto the land. There in the weaker wind the snow is deposited, augmenting snowfall.

Strips of snowfall heavier than inland are indicated on the west shores of Lakes Huron and Michigan in December, January, February, and the year (charts 5, 7, 9, 15). These are evidently from the easterly winds which come with heavy snow in the northeast quadrant of strong winter cyclones. The heavier snowfall in southern Wisconsin than in the center, spoken of by Prof. A. J. Henry (see p. 4), is not indicated on these charts. In February only is there a suggestion of this and on the annual chart (chart 15) there is no evidence of such a peculiarity.

In spring the warmth of the land relative to the water more or less counteracts the cooling tendency of on-shore winds and so tends to prevent precipitation. Thus the mid-winter areas of heavy snow on the east shore of Lake Michigan become in March and April strips of snowfall less than that received away from the direct influence of the lake (see charts 7, 9, 11, and 12). This effect is shown also by the diminishing percentage of snowfall with winds from the Lakes from February to March (see charts 8 and 10). In May, June, August, and September snowfall occurs in small amounts about the Lakes, particularly near Lake Superior and on the high land not far from the other lakes.

Most of the wind roses about the Great Lakes (charts 4, 6, 8, and 10) do not show any striking prevalence of snow with winds from the Lakes. Nevertheless, the snowfall is much heavier on the east shores than on the west. Although the surface wind may be from any direction during snowfall, still overhead atmospheric movements which are prevailingly from the west bring the moisture eastward from the Lakes. Furthermore, since the wind roses were made on the basis of the mere occurrence of snow at 8 a. m. without reference to the intensity of snowfall or to the force of the wind, they do not show which winds bring the major portion of the snowfall.

Conclusions.—In winter all parts of the Lake region are subject to snowfall from general cyclonic storms. Such storms may account for perhaps 30 inches of the annual means. The remainder is probably due to the effect of local topography on cold, moist winds. Thus the cold northwest winds of winter after crossing a lake deposit considerable snowfall on the eastern shores. The western shores get a little local snowfall from the infrequent northeast winds. The shore snowfall topographically produced, tends to reach a maximum early in winter when the winds from the relatively warm Lakes experience the greatest cooling on reaching land.

The snowfall of the Appalachian Mountains.

In the Appalachian region, the greater the altitude, the heavier is the snowfall, as a general rule. In the north, and even south to West Virginia, the higher country receives more than 100 inches a year. The high mountains of North Carolina apparently get less than 50 inches annually (see chart 15) (16). The average monthly snowfall reaches a maximum of about one-quarter of the annual, this maximum occurring usually in January, but in February in New England.

The monthly charts show the progressive advance and retreat of the snowfall lines from September to May. Snowfall has been recorded in June south to Virginia and West Virginia, and in August in the Adirondacks. Apparently no record of July snowfall in this region is contained in the published tables of the Weather Bureau from 1895 to 1913. However, snowfall in this month has occurred on Mount Washington at least (17).

While the temperature control of latitude and altitude on snowfall are important, the exposure to snow-bringing winds and the proximity of water surfaces to windward can not be overlooked. As examples, take three areas of very heavy snowfall in the Appalachians—the western Adirondacks, the southern Green Mountains, and the mountains of West Virginia.

The first is represented by the station Number Four, N. Y., situated at an altitude of 1,571 feet above sea level and freely exposed to the west. The mean annual snowfall there is 166 inches, as shown by eight years'

records. The month of heaviest snowfall is December, with 37 inches; January, February, and March all have more than 30. As was indicated in the discussion of the snowfall about the Great Lakes, leeward shores have heavy snowfall, and excessive snowfall where topographic features strongly force the ascent of moist winds. Number Four, close to Lake Ontario, with the other Great Lakes not far to windward, is excellently situated to receive heavy snowfall, which, with the topographic effect added, becomes profuse. Lowville, about 15 miles west of Number Four, nearer Lake Ontario, at an altitude of 900 feet above sea level, receives on the average (15 years) but 92 inches a year. Blue Mountain Lake, 40 miles east

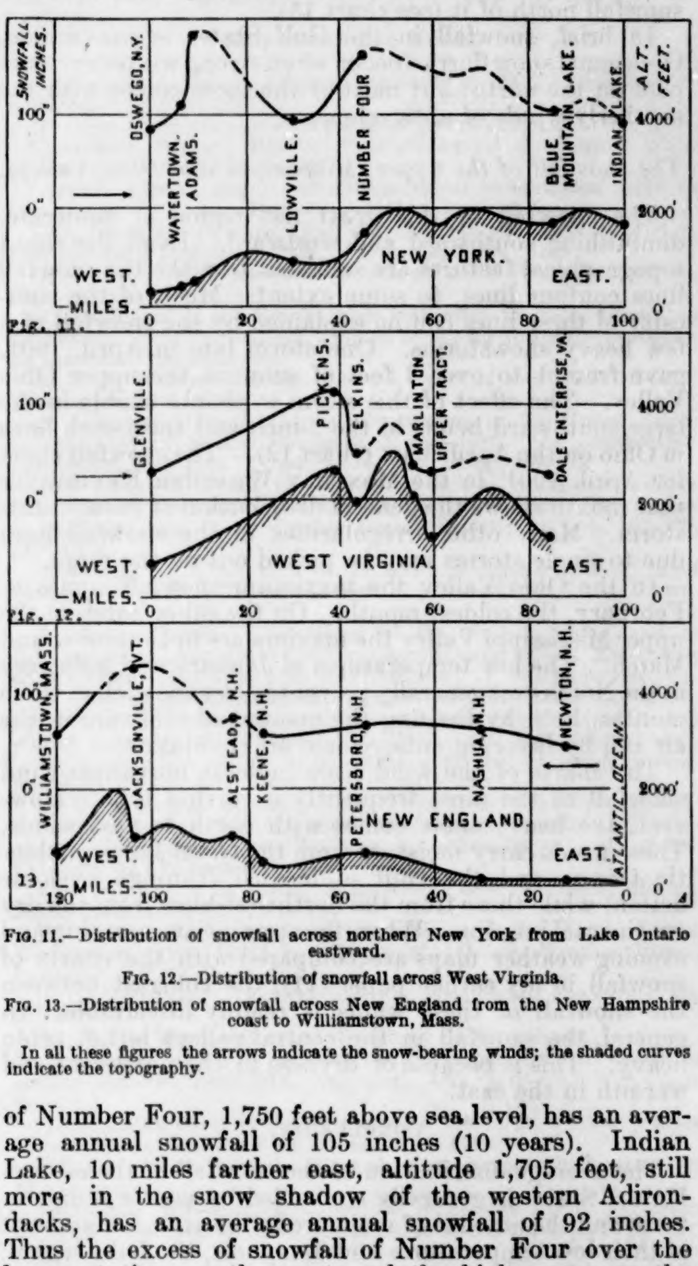


FIG. 11.—Distribution of snowfall across northern New York from Lake Ontario eastward.

FIG. 12.—Distribution of snowfall across West Virginia.

FIG. 13.—Distribution of snowfall across New England from the New Hampshire coast to Williamstown, Mass.

In all these figures the arrows indicate the snow-bearing winds; the shaded curves indicate the topography.

of Number Four, 1,750 feet above sea level, has an average annual snowfall of 105 inches (10 years). Indian Lake, 10 miles farther east, altitude 1,705 feet, still more in the snow shadow of the western Adirondacks, has an average annual snowfall of 92 inches. Thus the excess of snowfall of Number Four over the lower station on the west and the higher ones on the east may be ascribed to its altitude on the one hand and to its exposure on the other. The wavelike distribution of snowfall in northern New York, from Lake Ontario eastward, is quite marked. Figure 11 shows this graphically.

The second region, West Virginia, has its maximum snowfall at Pickens on the west slope of the Appalachians. Pickens is at an altitude of 2,785 feet above sea level and has an average annual snowfall of 111 inches (11 years). The wind roses for Elkins (charts 4, 6, 8, and 10) have the west wind prominent in every case, for when the moist winds of the Ohio Valley reach the Appalachians they are forced to ascend rapidly more than 2,000 feet, with the result that in winter snow usually falls with any strong west wind. The first ridge very apparently casts its snow shadow on the country behind, so that on the lee side the snowfall is the same at 1,000 feet elevation as at 700 feet on the windward side. (See fig. 12.)

The Green Mountains of Vermont become progressively snowier southward. This is not due to the increase in altitude, but to more open exposure to the moist easterly winds from the Atlantic. The snowfall at Jacksonville, Vt., 1,000 feet above sea level, on the east slope of the southern part of the mountains, represents the culmination of the effects of this exposure and of topography in this region. The average annual snowfall there is 124 inches (15 years). On the other side of the ridge, Williamstown, Vt., at 711 feet altitude, has but 50 inches of snowfall annually (16 years). Figure 13 is a general snowfall and altitude profile from the Atlantic Ocean across southern New Hampshire and Vermont to the west side of New England. The heavy snowfall at Jacksonville is probably caused by the east winds from the Atlantic and north winds from up the Connecticut Valley, passing over the mountains there. The east winds are moist and the north winds cold, and their passage over the mountains in southern Vermont is probably favored by the eastward turn of the Connecticut Valley at that point, which hinders a further southward flow of air. Places on the west side of the Green Mountains are in the snow shadows of both the Green Mountains and the Adirondacks, and so have relatively little snowfall. In northern New England west-wind snowfall is again encountered in large amounts where the winds from the St. Lawrence Valley cross the mountains. From these examples it is apparent that that free exposure to moist winds leads to heavy snowfall at a mountain station in winter.

The snowfall of the Atlantic coast.

The northeast snowstorm of the Atlantic coast is one of its emphatic winter characteristics. Whittier's "Snowbound" is the classic description of such a storm in New England. The snowfall of the north Atlantic coast is very heavy in some winters, but almost lacking in others. The average annual amounts (see chart 15) approach 100 inches in Maine but decrease rapidly southward. A short distance inland away from the tempering influence of the Atlantic and in a region cooler because of greater altitude, the snowfall is heavier than on the coast as was the case about the Great Lakes. At points still farther back the snowfall is less because they are beyond the pale of the coast snowstorms. Thus the snowfall in south central Maine is less than that on the coast and less than that of the higher land to the north. This is shown on the charts for February, March, April, and the year (charts 9, 11, 12, 15). The same effect is also shown on the coastal plain of Virginia and North Carolina in October (chart 2). October snowfalls have occurred in this coastal area not once but several times in the 18 years.

On the whole, the month of maximum snowfall is February, although January snowfall equals that of February on the middle Atlantic coast. For the south Atlantic coast nearly all of the snowfall represented on

the February chart came in February, 1899 (11, figs. 1–6). Even for the middle Atlantic coast, the omission of that one month in the whole period would mean a difference of 2 to 3 inches in the February and annual means. The snowfall lines on the April chart (chart 12) follow topography more closely than on any other. This may not be due so much to differences in the actual amount of snow fallen as in that which accumulated on the ground. For ground temperatures in spring and fall are such that, on a hill, snow will accumulate on the ground while in an adjacent valley but a few hundred feet lower, the ground may be just warm enough to melt the snow as it falls. Thus, on Blue Hill, Mass., the light snowstorms of fall and spring frequently cover the ground 2 inches deep, while, at the same time in the Boston basin a few miles north and but 500 feet lower, the snow melts as it strikes the ground. The accumulated effect of the difference due to altitude and city heat is such that Blue Hill has an annual snowfall mean of 58 inches as compared with 41 for Boston (1895–1913).

As is clearly shown on the December chart of snow-bearing winds (chart 4), snow on the immediate coast does not usually occur with the surface wind blowing off the comparatively warm ocean. Later, when the water has become relatively cold, snow occurs most frequently with easterly, particularly northeasterly, winds. Friction and topography become effective snow producers with the late-winter snow-bearing winds which blow on shore, as is the case with the snowfall about the Great Lakes. The delay of the maximum snowfall until February is due to the retarding effect of the ocean's heat. Coast cyclones are more generally accompanied by snow in this month than in any other.

Thus most of the snowfall on the Atlantic coast is the result of moist air from the Atlantic Ocean cyclonically and topographically cooled.

The snowfall of the Gulf States.

The snowfall of the Gulf States may be described as occasional. On this account the charts showing average snowfall per month or year give an erroneous impression. For instance, at Montgomery, Ala., a total of 14 inches of snow fell during the 18 years from 1895–1913. This came in only four months:

	Inches.
1899—January	3.5
February	3.0
December	3.5
1901—February	4.0

Amounts too small to measure occurred as follows:

	Times.
November	2
December	6
January	6
February	7
March	2
April	1

Thus the annual mean of 0.8 inch tells one almost nothing of the character of the snowfall at Montgomery. This is typical of the South.

Similarly, the data on which the wind roses were constructed (charts 4, 6, 8, and 10) are deficient. However, they do show that when the snow did occur it was, almost without exception, with a northerly wind. The snowfall which occurs with northwest winds is usually of the snow-flurry type, just as it is over most of the eastern United States. On the other hand, the snow which comes with a north or northeast wind is frequently heavy enough to accumulate on the ground (see charts 11 and 12).

Since unusually cold weather must prevail in the Gulf States to allow snowfall there, the snow generally occurs under high pressure conditions. A cold high pressure area over the southern Ohio Valley and the southern Appalachians necessarily sets up a convectional circulation with the warm air over the Gulf of Mexico. The result is precipitation that often starts as rain, but frequently becomes snow as the circulation increases in intensity. The storm of February 10–14, 1899, is an excellent illustration of the development of such a storm.

The effect of altitude on the snowfall of southern Alabama and Mississippi is shown by the snow "island" on the southern cuesta (see chart 12) and by the areas of less snowfall north of it (see chart 15).

In brief, snowfall in the Gulf States is uncommon. Occasional snow flurries occur when strong winter cyclones pass on the north; but most of the snow comes with the northerly winds of anticyclones.

The snowfall of the upper Mississippi and Ohio Valleys.

The snowfall of this great flat region is moderate, diminishing southward and westward. Even the slight topographical features are sufficient to make the snowfall lines contour lines, to some extent. Much of the sinuosity of these lines can be explained by the snowfall of a few heavy snowstorms. One storm late in April, 1901, gave from 1 to over 3 feet of snow in the upper Ohio Valley. The effect of this storm is plainly visible in the large southward bends of the 2-inch and the 1-inch lines in Ohio on the April chart (chart 12). The snowfall chart for April, 1901, in the MONTHLY WEATHER REVIEW for that month shows the general distribution of snow in this storm. Many other irregularities in the snowfall lines due to single storms may be picked out on the maps.

In the Ohio Valley the maximum snowfall comes in February, the coldest month. On the other hand, in the upper Mississippi Valley the maxima are in December and March. The low temperatures of January and February in the Northwest generally prevent heavy snowfall in these months, both by limiting the amount of moisture in the air and by favoring anticyclonic air circulation.

The charts of the wind roses indicate northwest-wind snowfall as the most frequently occurring type. However, the heavy snow comes with north to east winds. These winds carry moisture from the Great Lakes, Atlantic Ocean, and the Gulf of Mexico (through cyclonic action) while those from the northwest blow from the dry continental interior. When the appropriate morning and evening weather maps are compared with the charts of snowfall in my earlier paper (11), the contrast between the snowfall of these winds is readily discernible. In general, the snowfall in the central valleys is not often heavy. This is because of dryness in the northwest and warmth in the east.

CONCLUSION.

The average distribution of the snowfall of the eastern United States is generally controlled by winter temperatures and the amount of moisture in the air. On account of their low temperatures and dampness, the Lake region, Appalachians, and north Atlantic coast get the heaviest snowfall. On the other hand, the Ohio Valley, the south Atlantic and Gulf States are usually too warm for much snow. In the northwest the snowfall is moderate because of the winter dryness. Within these larger snowfall provinces, the snowfall is locally modified by the topography and the exposure to moist winds. Thus, the Appalachians get heavier snows on their western than on their

eastern slopes (except in Vermont), and the eastern shores of the Great Lakes get more snow than the western.

Snow generally falls in connection with winter cyclones, for the cyclonic action and the effect of topography on the winds cause precipitation. As the northeast wind is both cold and damp over practically the whole eastern United States, it is the wind of the great snowstorms. The northwest wind, although cold, is generally dry and so brings, at most, only snow flurries except locally on a windward mountain slope or in the lee of the Great Lakes. In brief, the main factors which control snowfall are temperature, moisture in the air, exposure to moist winds, local topography, and the passage of winter cyclones.

REFERENCES AND NOTES.

(1) *See also* American Almanac for 1837, p. 169-185: "Notices of remarkably cold winters."

(2) Some other journals with less extensive records are:

Cleaveland, Parker. Results of meteorological observations made at Brunswick, Me., 1807 to 1857.

Caswell, Alexis. Results of meteorological observations made at Providence, R. I., from December, 1831, to May, 1860.

Hill, Leonard. Meteorological and chronological register, 1806 to 1869 at East Bridgewater, Mass. Plymouth, Mass. 1869.

(3) *See* J. P. Espy's reports in the Journal of the Franklin Institute, Philadelphia, 1839 to 1841.

(4) *See* Report of the **Smithsonian Institution** for 1855: Directions for meteorological observations, adopted by the Smithsonian Institution for the First-Class observers.

(5) **U. S. Weather Bureau.** Annual report of the Chief, 1891-92. Washington, 1893, p. 447.

(6) A history of meteorological observations in the United States is attempted by Marcus Benjamin in the work "The Smithsonian Institution, 1846-1896" (Washington, 1897) on pp. 647-678.

More complete details are given by various authors before the International Meteorological Congress, held at Chicago, Ill., August 21-24, 1893. (*See* U. S. Weather Bureau Bulletin 11. pp. 207-220, 232-302.)

(7) **Volney, C. F.** A view of the soil and climate of the United States of America. Translated from the French by C. B. Brown. Philadelphia, 1804.

(8) **Blodget, Lorin.** Climatology of the United States, and of the Temperate Latitudes of the North American continent. Embracing a full comparison of these with the climatology . . . of Europe and Asia. . . . Including a summary of the statistics of meteorological observations in the United States condensed from recent scientific and official publications. Philadelphia. 1857. xvi, [17]-536 p. 4°.

An appreciation of this monumental work will be found in the MONTHLY WEATHER REVIEW, January, 1914, **42:** 23-27.

(9) **U. S. Weather Bureau.** Rainfall and snow of the United States as compiled to the end of 1891, with annual, seasonal, monthly, and other charts. Text and Atlas. Washington. 1894. 80 p. 4°. Atlas: 23 charts, 18 x 24 inches.

This publication is reviewed in Amer. meteorol. jour., Boston, Mass., June, 1895, **12:** 71-2.

(10) **Henry, A. J. & others.** Climatology of the United States. Washington. 1906. 1012 p. 33 pl. 4°. (U. S. Weather Bureau bulletin "Q." W.B. no. 361.)

(11) *See* MONTHLY WEATHER REVIEW, Washington, June, 1914, **42:** 318-330.

(12) **U. S. Weather Bureau.** Summary of the climatological data for the United States by Sections 106 [sections]. Printed at various section centers. 1908-1912. var. pag. 4°. (Bulletin "W." W.B. no. 476.)

(13) Such an effect is clearly shown on the U. S. Weather Bureau "Snow and Ice Bulletin" for December 30, 1913.

(14) For a thorough study of the physical changes which take place in a snow-cover, *See* —

Jansson & Westman, J. Quelques recherches sur la couverture de neige. Bull., Geol. instit. of Upsala, 1901, No. 10, **5**, pt. 2, pp. 234-260.

(15) *See* MONTHLY WEATHER REVIEW, November, 1911, **39:** 1671; also Chart VIII in the REVIEW for November, 1911.

(16) The United States Forest Service official living at an altitude of 5,060 ft. on Mount Pisgah, N. C., 18 miles southwest of Asheville, N. C., recently told the writer that the snow accumulated on the ground, sometimes to a depth of 3 feet, and that in one night a snowfall of 27 inches occurred. The similarity between these extremes and those met in eastern Massachusetts, suggests that the average snowfall in the southern Appalachians may be about 50 inches annually.

(17) **Greely, Adolphus W.** American Weather. p. 162.

I.

THE RAINFALL OF THE NORTHEASTERN UNITED STATES.

By B. C. WALLIS, B. Sc. (ECONOMICS), F. R. G. S., F. S. S.

[Dated: North Finchley, England, Sept. 21, 1914.]

THE METHOD OF INVESTIGATION.

Probably the two most important considerations regarding the rainfall of any area are its total quantity and its distribution through the year. Attention is called in this paper to the second consideration, and an attempt has been made to measure the distribution by means of the statistical method of differences. The amount of rainfall which would be precipitated at a given place, upon the assumption that such rainfall were evenly distributed through the year, has been taken as a *norm*. This *norm* is obtained by dividing the total annual fall by 365, and by multiplying the quotient by 28, 30, and 31, respectively, to obtain the numbers which represent the norms for the month of February, and for the 30- and 31-day months. The value of the norm has been taken for each month for all places as 100, so that in the accompanying maps (figs. 2-5, 12-23),

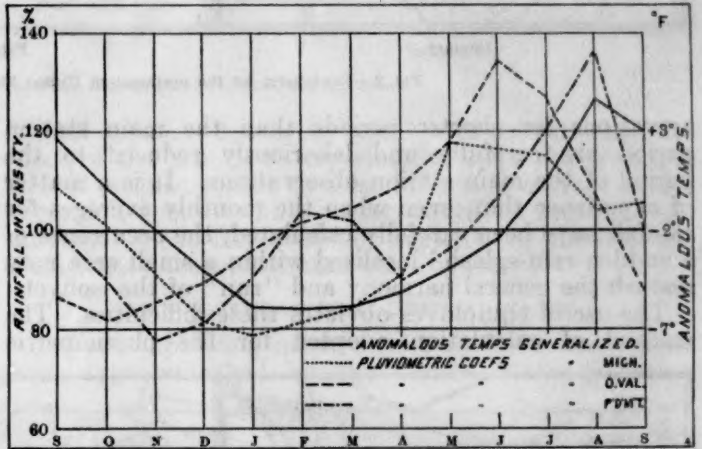


FIG. 1.—Annual march of pluviometric coefficients for Michigan, Ohio Valley, and the Piedmont compared with the annual march of the temperature anomalies for the northeastern United States.

the line which is marked 100 indicates that the rainfall at all places along that line is the norm for the month. Differences from the norm are expressed as percentages. Suppose the norm for a given place for January is $2\frac{1}{2}$ inches, and the actual average rainfall at that place for January is 3 inches; then since, when $2\frac{1}{2}=100$, $3=120$, the difference for that place for January is 120, which implies that during January at that place the precipitation is 20 per cent above the norm; i. e., January is a relatively wet month.

The name "pluviometric coefficient" has been given to this quantitative expression by Dr. A. Angot, who is responsible for this application of the method of differences to rainfall studies. When pluviometric coefficients are indicated upon maps, upon the same principles as isohyets, the lines of equal departure from the rainfall norm have been called by the present writer "equipluves," [1] using a Latin term for the sake of greater

[1] Mr. Ernest Gold (4) has pointed out that the "pluviometric coefficient" is "the ratio of the mean daily rainfall of a particular month to the mean daily rainfall of the whole year."

The term "isomer" has been suggested by Mr. C. Salter (4) in place of the term "equipluve" coined by Mr. Wallis. If the former term is used one should be careful to preface it with the word "rainfall" or "precipitation," since in itself "isomer" does not suggest a quality of rainfall. This disadvantage is absent from the term "equipluve."—[C. A., jr.]

distinctness. The accompanying maps show the equipluves for the several months for the northeastern United States.

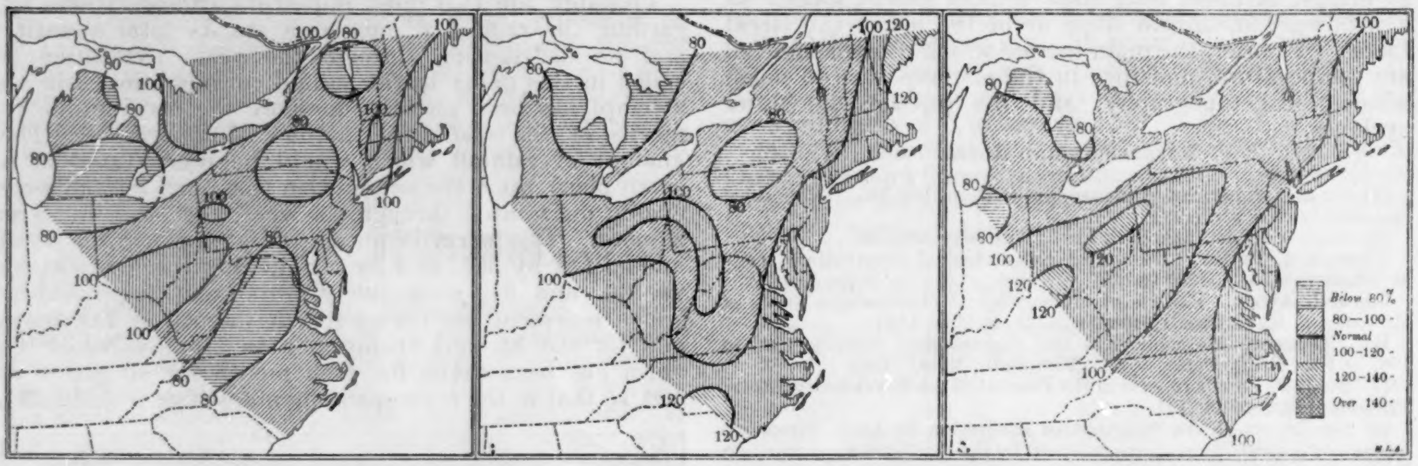
Equipluves in contrast with isohyets.—It has been laid down that monthly rainfall maps, where the rainfall is indicated by means of isohyets, are of little value unless (1) the observations have been taken over a long series of years, which should approximate to 50, and (2) observations for shorter periods than the main station period are carefully and laboriously reduced to the period of the main station observations. It is a matter of experience that, even when the monthly averages for rainfall have been carefully calculated, the occurrence of a sudden rain-splash[2] localized within a small area may disturb the general harmony and "run" of the isohyets.

The use of equipluves obviates these difficulties. The method of calculation adopted for the pluviometric coefficients smoothes out the accidental rain-splashes, and at the same time it tends to bring the values obtained during a dry series of years into closer harmony with the values obtained during a wet series of years. Consequently, the method of differences tends to allow the student to neglect all interpolative calculations in order to bring his values to the average required for a constant period of years.

[2] See an extract from H. R. Mill on p. 24, below.

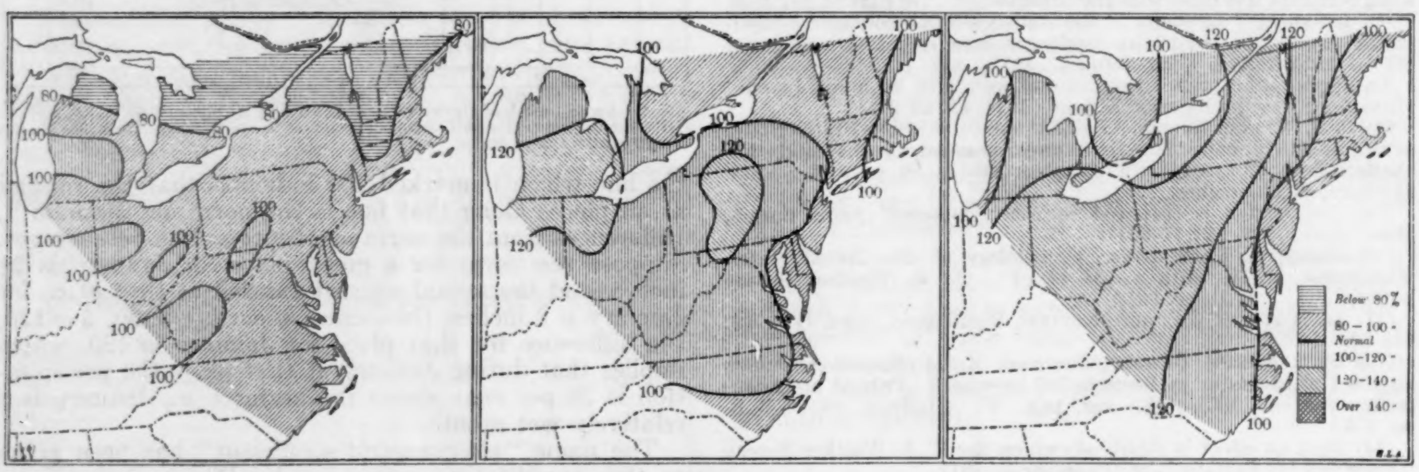
Suppose we divide the places of which there are rainfall records into three classes: (*a*) where the records have been kept for from 40 to 50 years, (*b*) where the records have been kept for from 20 to 40 years, and (*c*) where records have been kept for less than 20 years. When the maps are under construction, all stations in class (*a*) will be entered first, and the general run of the equipluves can then be determined; stations in class (*b*) will next be entered in all those cases where the values are in general harmony with the run of the equipluves; and stations in class (*c*) will be used to determine the run of the equipluves when other observations fail. In figures 2–5 accompanying this paper the "equipluves" are drawn at 20 per cent intervals, and it rarely happens that places in classes (*b*) and (*c*) differ by more than 10 per cent from the general average values of surrounding places. Consequently, in actual practice, most of the records can be utilized directly without resorting to methods of interpolation.

The utility of equipluves.—To express with some precision the aspect regarding rainfall which is under investigation the term "rainfall intensity" is used; and it may be urged that it is exactly rainfall intensity throughout the year which is the most important fact regarding rainfall, when once the average annual precipitation has been determined.



January. February. March.

FIG. 2.—Equipluves for the northeastern United States for the months of January, February, and March.

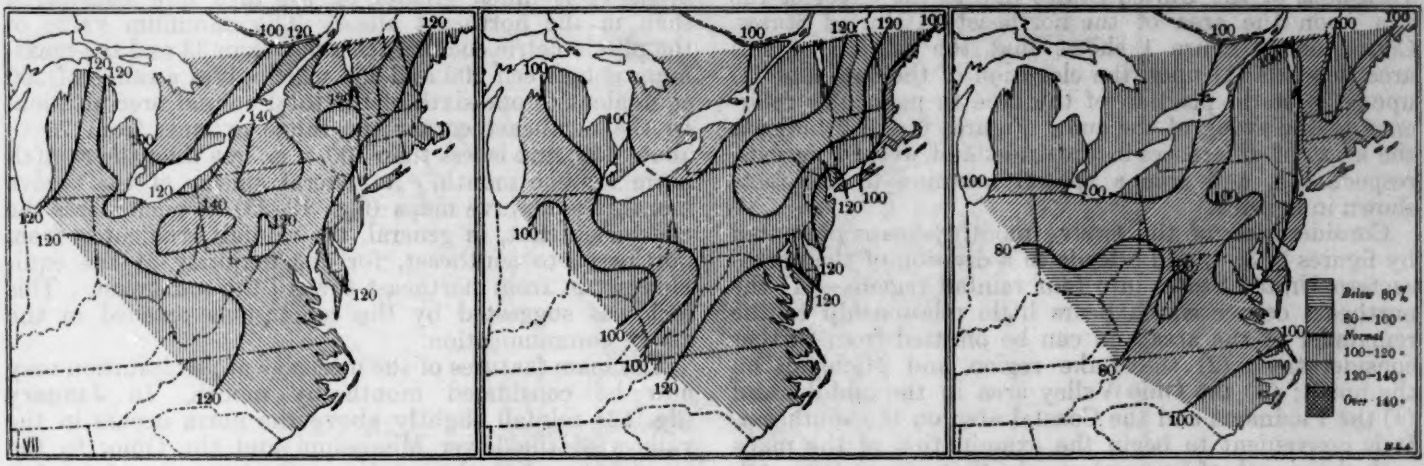


April. May. June.

FIG. 3.—Equipluves for the northeastern United States for the months of April, May, and June.

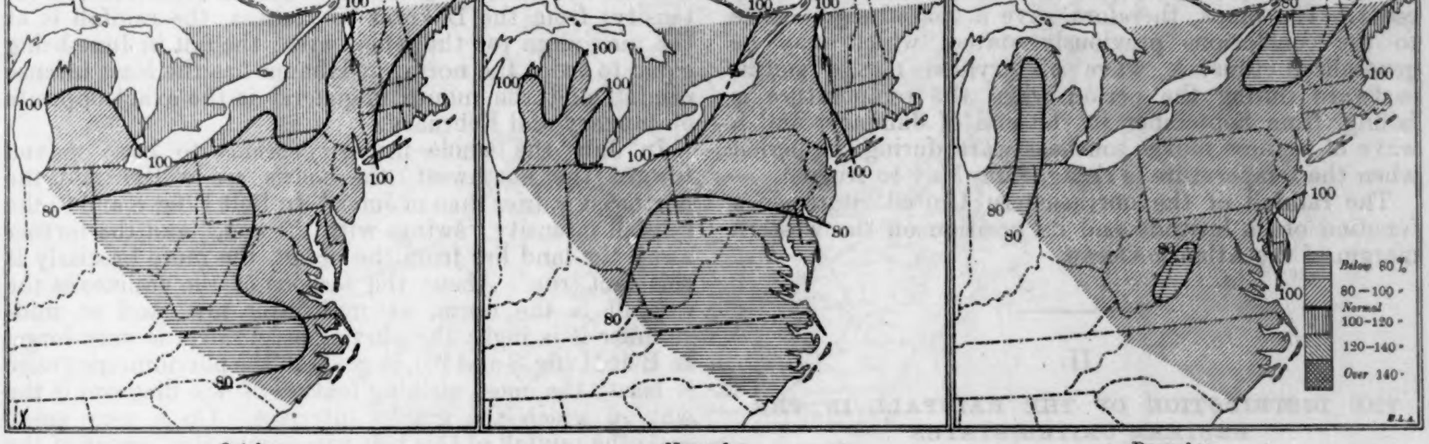
In another paper (1) the writer has studied the rainfall of the continent of Africa and finds the rainfall sequence throughout the year is related to the swing of the sun; also that the two portions of the continent north and south of the Equator present precisely similar general rainfall features. It has further been determined, in regard to the area of Africa where the actual annual total precipitation is heaviest, that the rainfall intensity is of the same magnitude as in the desert where the actual precipitation is least. There is also, in all probability, little difference in magnitude and intensity between the rainfall of Africa between the desert areas and the "monsoon" rainfall of India.[3] In another paper (2) it has been demonstrated by the same methods that the continent of Australia presents similar features regarding its rainfall to those previously determined in the case of Africa. Now the question arises whether the intensity of the rainfall in areas outside the limits of parallels 40°N and 40°S yields similar features; e. g. whether the pluviometric coefficients ever reach the magnitude of 300 and over; whether the rainfall intensity depends mainly upon the altitude of the sun.

In a third paper (3) it has been pointed out in the case of the district of the Southern Pennines in northern England that the intensity of the rainfall varies with the relief of the land. Wherever the land is lowland, the annual rainfall is relatively small and the highlands are relatively wet; but the wet districts have a greater rainfall intensity in winter than the dry districts, while the dry districts have a more intense rainfall in summer than the wet districts. Assuming that the sequence of rainfall intensity upon the lowlands is the average rainfall sequence due to the influence of the sun, then the effect of the hills is to superimpose upon the [average] rainfall [sequence] due to solar influences a great excess of rainfall upon the hills during the colder months. At the same time in this district of England the pluviometric coefficients have a maximum value of 150.



July. August. September.

FIG. 4.—Equipluves for the northeastern United States for the months of July, August, and September.



October. November. December.

FIG. 5.—Equipluves for the northeastern United States for the months of October, November, and December.

THE NORTHEASTERN UNITED STATES.

The accompanying maps (figs. 2-5) have been made from data published by the United States [Weather Bureau] in order to investigate the rainfall conditions upon the western margin of the Atlantic Ocean in relation to the results obtained for England and Africa. Figure 1 is based upon these maps. It gives the rainfall results in a general way and indicates that the rainfall on the whole "swings with the sun" and that the main effect of the uplands between the Ohio Valley and the Piedmont is to bring the rainfall sequence of the latter a month later in the year. The line marked "anomalous

[3] See an extract from the author's paper (1), reprinted on p. 24 below.

temperatures," which is based upon a series of maps published in paper (1) indicates for this portion of the United States the amount of variation, month by month, from the average temperature round the world in similar latitudes. This average temperature in similar latitudes measures air temperatures as a function of latitude; variations from average temperatures—i. e., anomalous temperatures—indicate the local temperature variations of the United States due to the effect of the sun upon the area of the northeastern United States. Consequently figure 1 shows that the rainfall of this area depends (1) upon the elevation of the sun, and (2) upon the world position of the area in particular reference to the swing of the sun. Figures 6 and 7 indicate the areas of differences in the driest and wettest periods, respectively, and give a spatial meaning to the facts shown in figure 1.

Consideration of the twelve monthly maps presented by figures 2, 3, 4, and 5 leads to a division of the northeastern United States into four rainfall regions—(1) the northeast corner which bears little relationship to the remainder of the area and can be omitted from further consideration; (2) the Lake region and Michigan on the north; (3) the Ohio Valley area in the middle, and (4) the Piedmont and the Coastal area on the southeast. It is convenient to begin the examination of the maps with the month of September. In that month the north (2) and the coast (4) are of average wetness, but the Ohio Valley (3) is relatively dry. In October the dryness is more extensive and reaches almost to the southeast [the South Atlantic] coast. In November the dry conditions have moved still farther eastward. In December the rainfall is very little removed from normal (100 per cent) everywhere. In January the Ohio Valley is wetter than the neighboring hills, and beyond the hills there is a still drier region. In February the coastal lands are wet and the north is dry. In March the Ohio Valley shows signs of greater wetness, which persists during April.

In May the north is the wettest region; this relative wetness spreads eastward by June and becomes more intense by July. In August the wetness has reached the coast. The maps, therefore, give a spatial significance to the conclusions previously stated, which may be generalized thus: A wave of dryness moves southeastward during the period when the temperature is falling, from September to the end of January, and a wave of wetness moves southeastward during the period when the temperature is rising, from May to August.

The rainfall of the northeastern United States is a function of its latitude and its position on the western margin of the Atlantic Ocean.

II.

THE DISTRIBUTION OF THE RAINFALL IN THE EASTERN UNITED STATES.

By B. C. WALLIS, B. Sc. (Economics), F. R. G. S., F. S. S.

[Dated: North Finchley, England, Nov. 24, 1914.]

In the preceding paper the sequence of the intensity of the rainfall was described in reference to the northeastern corner of the United States. This area includes the major portion of the industrial area of the United States and is a region of diverse farming operations; in the present communication the area which includes the cotton belt and the greater portion of the wheat belt has been added to the area previously described, and the rainfall of the whole area is now considered in a broader view and with less detail than was possible in regard to the northeast. The method of calculating pluviometric coefficients has already been described, so that it is possible to pass at once to the statement of the conclusions to be drawn from the accompanying maps and diagrams (figs. 6–23).

It should be noted, first, that the range of the rainfall intensity is much greater in the area now considered than in the northeast alone. The minimum value of the pluviometric coefficients is less than 33 and the maximum is between 200 and 233 which gives a range of 200 equivalent to one-sixth of the total annual precipitation. In the northeast corner the range extends from 70 to about 150, and is less than 100, i. e., less than the rainfall norm for one month. A general survey of the twelve monthly equipluve maps (figs. 12–23) at once forces the conclusion that, in general, the rainfall gradient is from northwest to southeast, for the majority of the equipluves run from northeast toward the southwest. This fact was suggested by the conclusions reached in the above communication.

The main features of the intensity of precipitation may now be considered month by month. In January (fig. 12) rainfall slightly above the norm occurs in the valleys of the lower Mississippi and the Ohio; to the southeast and to the northwest the intensity of rainfall diminishes. In February the area of rainfall above the norm has extended toward the coast and in Alabama and Georgia the rainfall is most intense; elsewhere there is little change from January. In March, except for an increased intensity in the Dakotas and along the coastal lowlands near Chesapeake Bay there is slight change from February.

In April, west of the Mississippi, the rainfall is above the norm, and the area east of that river tends to be drier. In May there is a marked increase in the intensity of the rainfall especially in Oklahoma and South Dakota; in general, the intensity of the rainfall increases with the distance from Florida. In June the southeast coast States and the northwest States show a marked increase in intensity; from the Dakotas to Kansas, the rainfall is at the maximum for the whole area, the fall in June being equal to twice the norm. Alabama has the least intense rainfall and the month in general is the exact opposite of January and February.

In July the whole intensity seems to have moved toward the northwest, the coasts are wetter and the northeast is drier than in June. In Belt I (fig. 8 and 9) the rainfall intensity "swings with the sun," and the farther away the land lies from the ocean, the more precisely is this fact true. About the seasons of the equinoxes the rainfall is the norm, at midwinter low, and at midsummer it is high; the pluviometric range is very large. In Belt II (fig. 8 and 10), in general, the pluviometric range is least; the most striking feature of the diagram is the way in which the graphs interlace. On a very small scale the rainfall of this belt varies with the "swing of the sun." The whole of this belt is marked by a comparative steadiness of the precipitation throughout the year; it forms a striking illustration of the phrase "rainfall at all seasons." In Belt III (fig. 8 and 11), the pluviometric range is intermediate between those in the other two belts and the distribution of the rain is unequal. From November to July, i. e., about two-thirds of the year, the rainfall intensity increases by two stages which are separated by a slight fall near the spring equinox. The intensity drops suddenly from August to November.

FIG. 6.—Map of the driest months in the eastern United States.

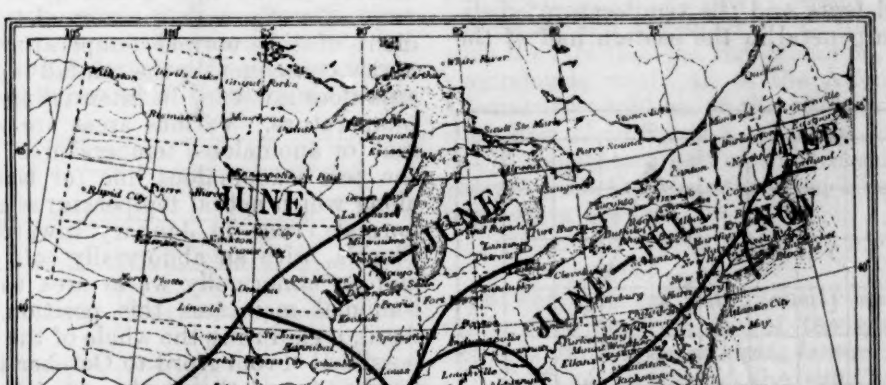


FIG. 7.—Map of the wettest months in the eastern United States.

FIG. 8.—Map of the rainfall regions of the eastern United States.

RAINFALL INTENSITY AND TEMPERATURE.

It will be well for a moment to consider the relation between the observed facts and the temperature conditions which prevail in general in the eastern half of the United States.

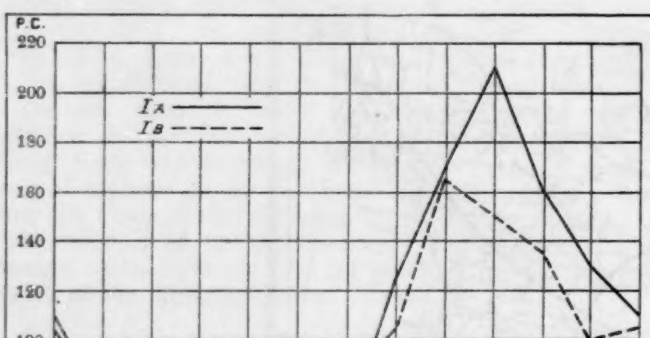


FIG. 9.—Annual march of rainfall intensity in Rainfall Regions *IA* and *IB*. (See fig. 8.) P. C.=pluviometric coefficients.

Temperature may be considered from two points of view:

(1) The normal temperature for the latitude of a place;

(2) The abnormal variations in different months which separate areas experience as a result of definite local conditions.

Normally the temperature of a latitude "swings with the sun," consequently in the northwest corner of our district (*IA* on figs. 8 and 9) intensity of the rainfall varies directly with the normal temperature.[4] The gradient of this normal temperature runs from south to north, consequently the rainfall in general over the whole area does not vary in intensity in simple relation to the temperature. Various areas are affected by the abnormal [or anomalous] temperatures. In the United States the zero isanomalous line (or isanomal), i. e., the line along which actual temperatures agree with the latitude normals, runs in January toward the northwest from Florida, with an abnormally cold area to the northeast and an abnormally warm area to the west. This zero isanomal maintains this position from December until April, i. e., during the whole of the period when frosts are possible. From April to October this zero line is shifted bodily toward the northeast, so that the area of abnormal (anomalous) warmth covers an increasingly large portion of the United States; in August, when this area is largest and also warmest it covers practically the whole of the United States.

It follows then from this fact that the movement of the date of maximum rainfall from June to August (fig. 7) agrees with the gradual spread, in the same direction, of an area of abnormal (anomalous) warmth, so that the delay of the season of maximum rainfall intensity until it is later than the period of maximum elevation of the sun accompanies this delay in the autumnal fall in air temperature.

The zero isanomal swings back to its January position by October and beyond it in November, so that in November practically the whole of the eastern half of the United

[4] The author uses this term here in the sense of "the *normal temperature of the given parallel of latitude*" as that expression is used in Ward's translation of Hann's Handbuch der Klimatologie, 2d ed. New York, 1903, p. 199. See the paper under (1) where is given a table of monthly normals for latitudes and monthly charts of isabnormals for the world.—[C. A. Jr.]

States is abnormally cold; the temperature drop in this region is, therefore, specially rapid from September to November. In August there is everywhere a general tendency to a decline in intensity from the previous month. In September the drop denoted for August becomes more marked except near the borders of Mexico. In October the eastern United States is in general drier than in September.

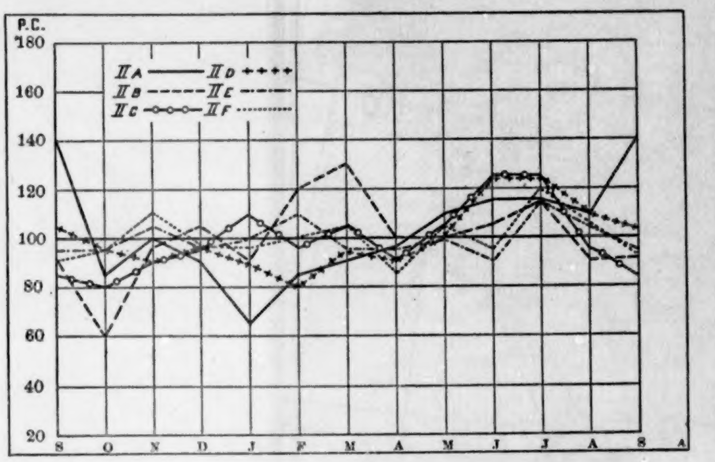


FIG. 10.—Annual march of rainfall intensity in Rainfall Regions *IIA–IIF*. (See fig. 8.) P. C.=pluviometric coefficients.

In November it seems as if the whole intensity of the rainfall had moved toward the southeast, the exact opposite of May. In December there is a further movement toward the southeast. In general, when the temperature is increasing, rainfall intensity increases in all directions from Alabama and Mississippi, and conversely when the temperature is decreasing.

The general conclusions which may be drawn from these 12 maps are indicated on the maps forming figures 6–8. Figure 6 shows that except in the extreme northeast the driest month varies in three broad bands

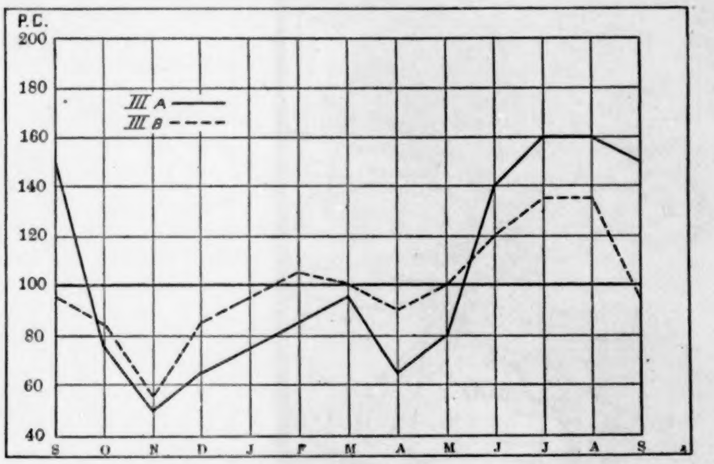


FIG. 11.—Annual march of rainfall intensity in Rainfall Regions *IIIA–IIIB*. (See fig. 8.) P. C.=pluviometric coefficients.

stretching across the general pluviometric gradient. On the northwest, January, in the Mississippi and Ohio valleys, October, and along the coast November is the driest month. Figure 7 shows that, in general, the three broad bands persist with a subdivision of the middle band; so that with the exception of Tennessee, Alabama, etc., the date of maximum rainfall tends to become later as the coast is approached from the northwest. Figure 8 results from an attempt to distinguish various rainfall regions based upon the foregoing observations. The northwest and the coastal bands are divided into two areas, and the middle band—including the northeast corner—is divided into six separate areas.

The details of the variation in intensity month by month are shown in figures 9–11, which should be studied in connection with the maps of figures 12–23.

Only in November is the temperature of the coast lands abnormally low and this fact is connected with the minimum rainfall intensity of Belt III (figs. 8 and 11) in that month. It should also be pointed out that in general the isanomalous lines of +5°F. and −5°F. coincide in direction with that of the pluviometric gradient.

In sum, it may be concluded with regard to the rainfall Belts I and II (see fig. 8) that their rainfall intensity depends upon temperature, and varies directly with the temperature. When the temperature is anomalous, the rainfall is anomalous, i. e., it varies from the standard rainfall which may be indicated by such a graph as *IA* of figure 9.

The anomalous temperatures which occur in the atmosphere are chiefly due to proximity to the oceans, so that the rainfall of Belt III, figure 8, is profoundly affected by the nearness of this belt to the Atlantic Ocean. Inland from the coast the effect of the ocean diminishes, coastward from the Dakotas the effect of the continental land mass diminishes, and the net result of these two facts is seen in the rainfall of Belt II where the interlacing of the graphs in figure 10 is evidence of the clash between the causes which govern the intensity of the rainfall. It is possible in many cases to connect the slight fluctuations in the intensity of the rainfall, as shown in figure 10, with the fluctuations in anomalous temperature; e. g., the average rainfall intensity of November and December (P. C. 100, fig. 10) is connected with the fact that the zero isanomal, which separates the anomalously warm air of the Atlantic Ocean from the anomalously cold air of the Hudson Bay area, coincides with Belt II in figure 8. Finally the total annual rainfall of the eastern half of the United States decreases in general with the distance from Florida, i. e., with distance from the sea.

SUMMARY.

In fine, the rainfall intensity as well as the actual amount of precipitation of the eastern United States depends upon three separate factors:

(1) The "swing of the sun," which has its most marked effect at places farthest from the sea;

(2) The local variations in temperature which give rise to abnormal temperature conditions, which have their most marked effect in causing variations in the months of maximum and minimum intensity of rainfall;

(3) The proximity of the ocean which causes heavy total precipitation near the coast and masks to some degree the effect of insolation.

Thus, there are the three rainfall belts shown by figure 8, viz:

I, a belt of summer rains and winter dryness;

II, a belt of rainfall at all seasons, due to the middle position of the area between the continental conditions of Belt I and the oceanic conditions of Belt III;

III, a belt of masked summer rains.

FIG. 12.—Equipluves for the eastern United States for January.

FIG. 13.—Equipluves for the eastern United States for February.

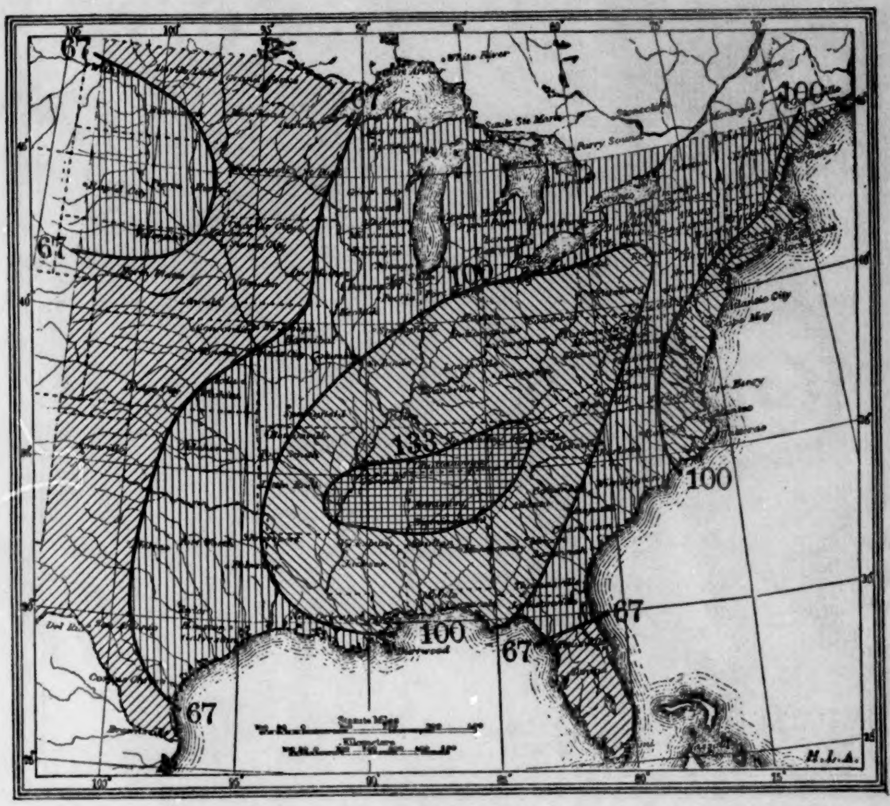


FIG. 14.—Equipluves for the eastern United States for March.

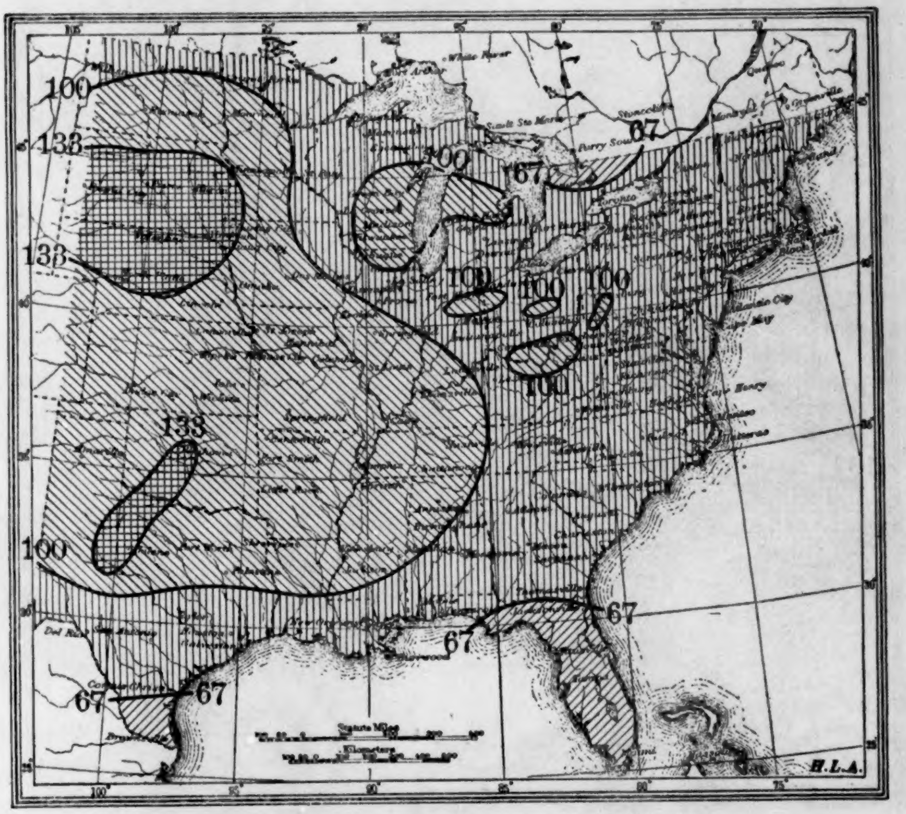


FIG. 15.—Equipluves for the eastern United States for April.

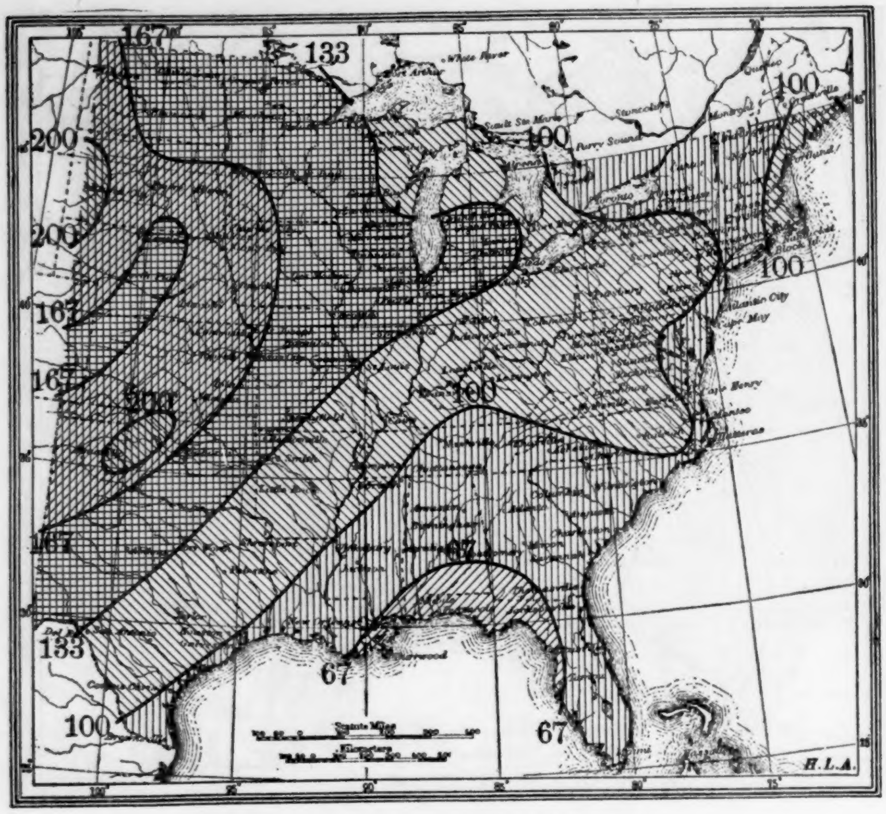


FIG. 16.—Equipluves for the eastern United States for May.

FIG. 17.—Equipluves for the eastern United States for June.

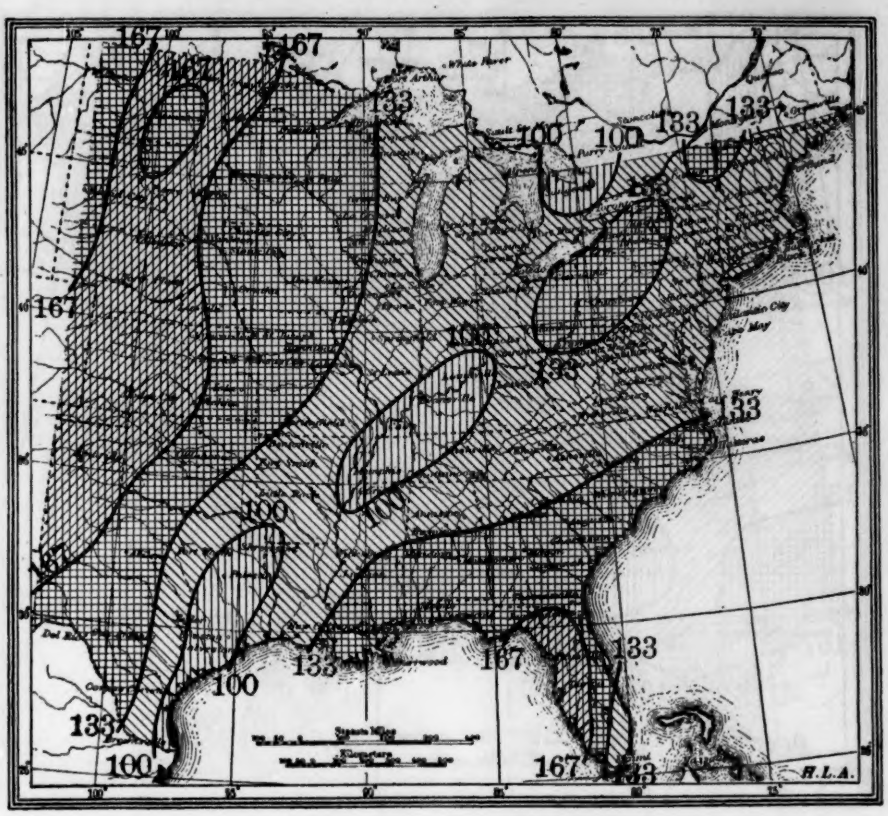


FIG. 18.—Equipluves for the eastern United States for July.

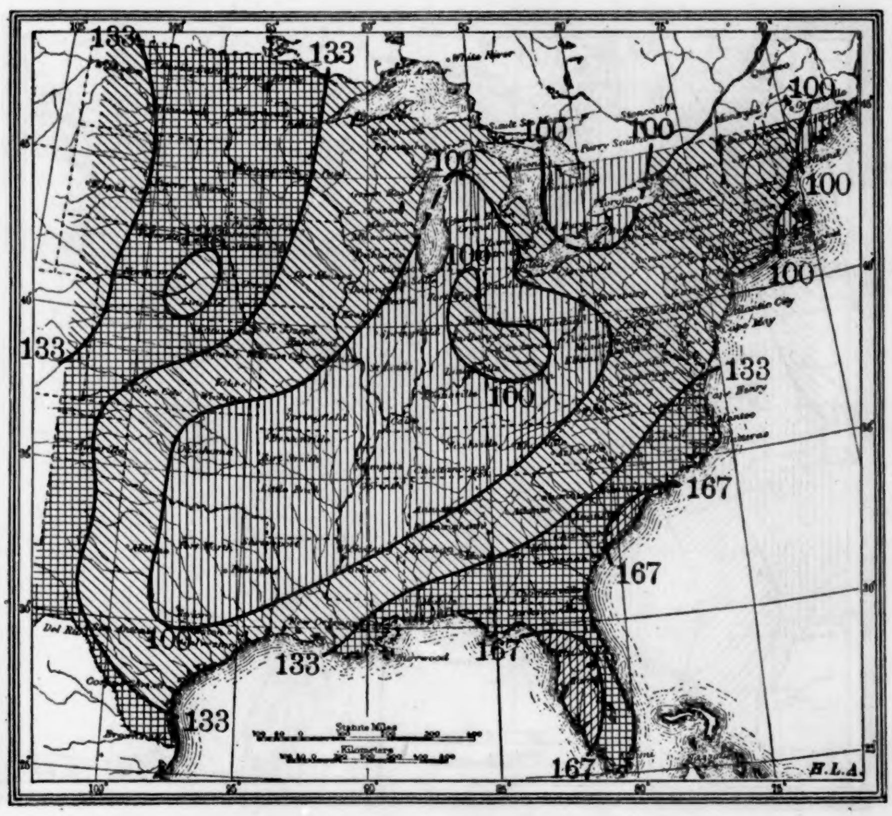


FIG. 19.—Equipluves for the eastern United States for August.

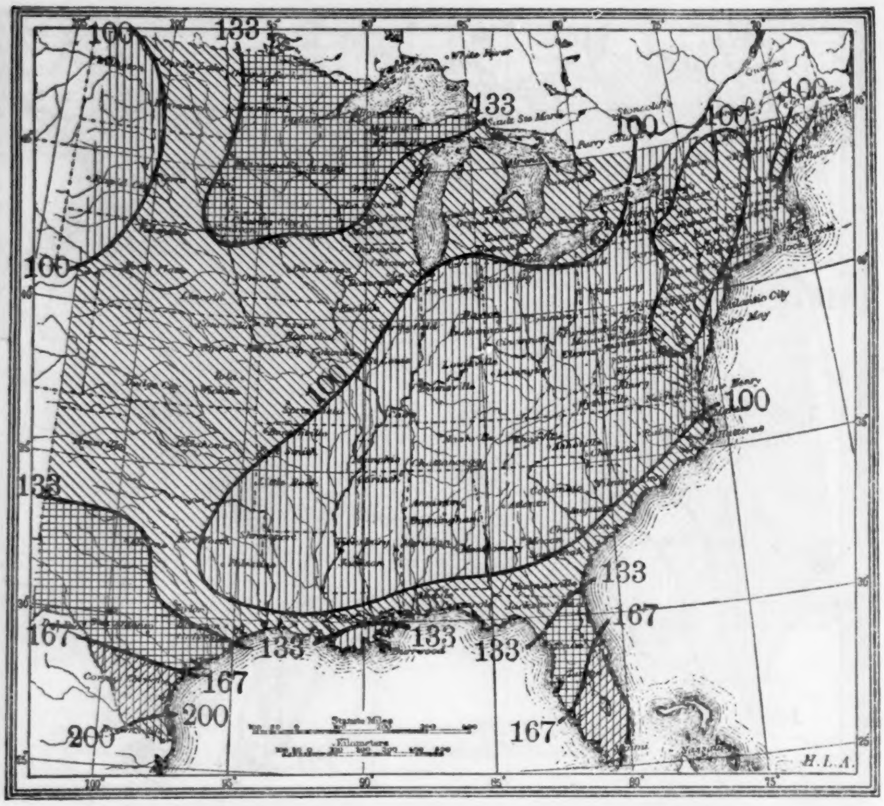


FIG. 20.—Equipluves for the eastern United States for September.

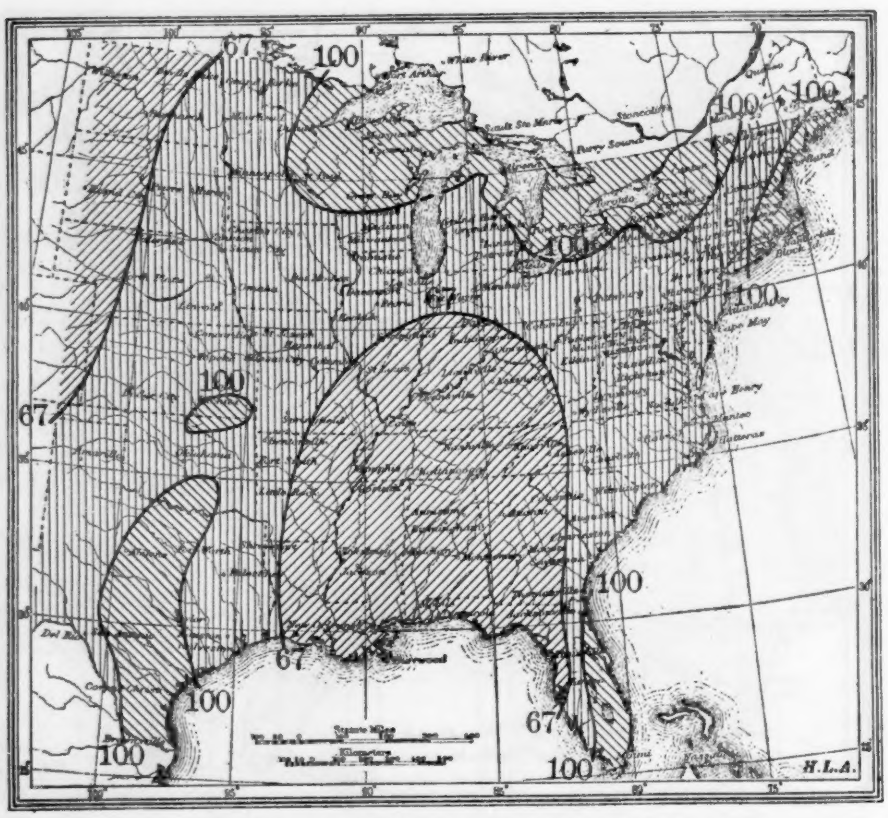


FIG. 21.—Equipluves for the eastern United States for October.

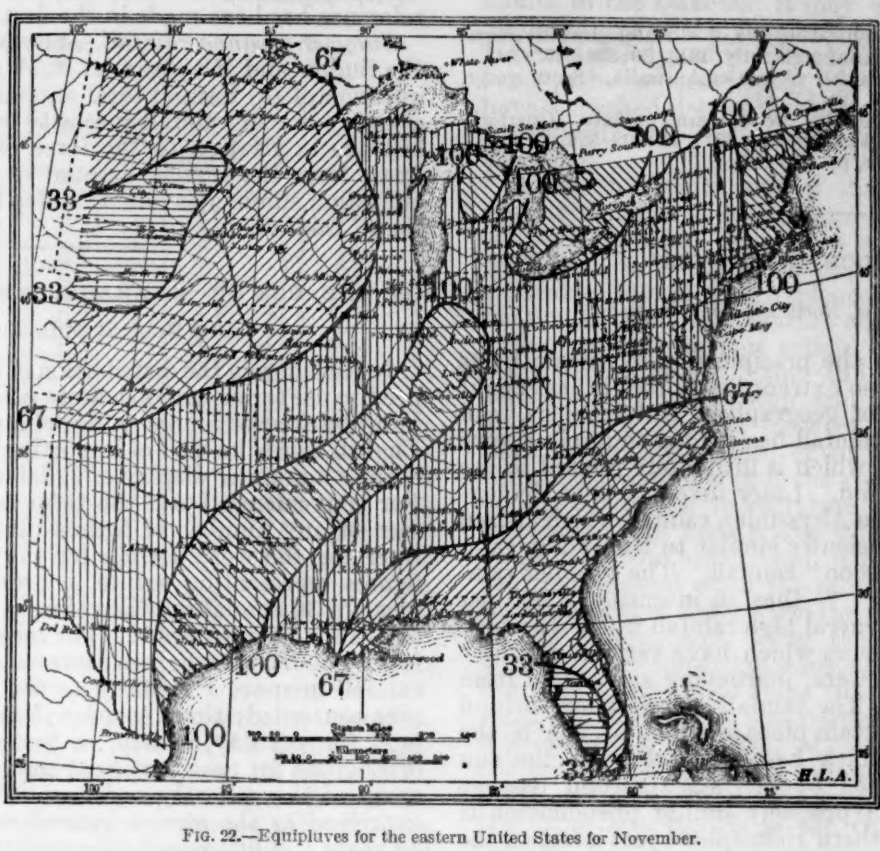


FIG. 22.—Equipluves for the eastern United States for November.

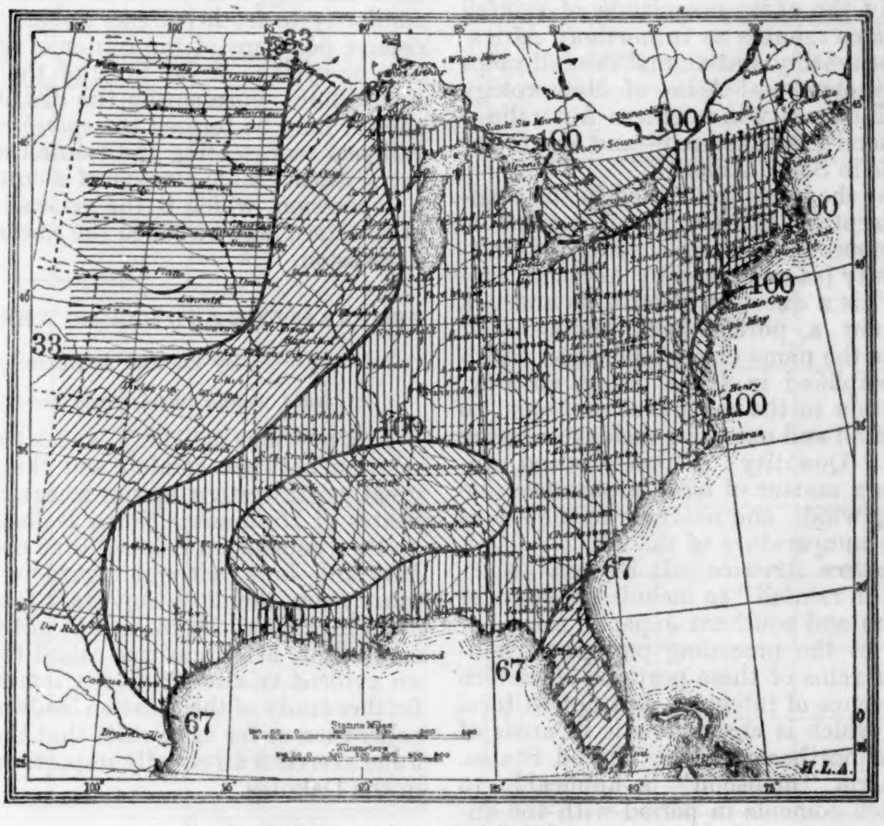


FIG. 23.—Equipluves for the eastern United States for December.

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(1) **Wallis, B. C.** Georgraphical aspects of climatological investigations. Scott. geogr. mag., Edinburgh, July, 1914, **30**: 356–369.
(2) **Wallis, B. C.** The rainfall régime of Australia. Scott. geogr. mag., Edinburgh, Oct., 1914, **30**: 527–532.
(3) **Wallis, B. C.** The rainfall of the southern Pennines. Quarterly jour., Royal metl. soc., London, October, 1914, **40**: 311–326.
(4) Discussion of (3) above, pp. 323–325.

"MONSOON" RAINFALL.[1]

By B. C. WALLIS, North Finchley, England.

The total volume of the precipitation in certain parts of India is apparently so extraordinary that it has caught the special attention of geographers and teachers, and the term "monsoon" rainfall has tended to imply a very special type of rainfall which is intimately related to the southwest monsoon wind. Later investigations demonstrated the fact that the Abyssinian rainfall which caused the Nile flood was sufficiently similar to the Indian rainfall to be called "monsoon" rainfall. The summer rainfall in Abyssinia * * * [has an intensity of 300 per cent] agreeing with a general high rainfall intensity which is reached by those places which have vertical sunshine when the sun is, as it were, journeying southward from the Tropic of Cancer. The rainfall intensity lags behind the sun, so that at a certain place south of lat. 23½°N. the maximum intensity which has been following the sun northward is reenforced by the sun's second passage through the zenith. A precisely similar phenomenon is to be noted in the Southern Hemisphere just north of the Tropic of Capricorn.

Now the pluviometric coefficients for Indian rainfall tend to show precisely the same magnitude of rainfall intensity during the same months as in northern Africa A rough glance at the monthly and annual rainfall maps of the world in [Bartholomew's] Atlas of Meteorology shows a similar rainfall intensity in northern Australia—where the term "monsoon" rains is used—and also in the belts of similar latitude in South America.

Hence it follows that the maps [published in the original whence this is excerpted] lay bare one of the factors in connection with monsoon rains in India; the incidence of rainfall intensity [as expressed by Angot's "pluviometric coefficients"] is a question of latitude and is a world phenomenon, not a purely local Indian fact. "Monsoon" rainfall, as the name of a phenonenon which is most typically exemplified in India, refers entirely, when regarded in relation to the southwest monsoon, to the *quantity* of the rainfall and not to its incidence during the summer months. Quantity of precipitation appears, therefore, to be a matter of *local* importance due to elevation, prevailing winds, and nearness to the sea as well as to the average temperature of the air.

Eastern Asia and eastern America.—It is usual to extend the term "monsoon rainfall" to include the summer rains of northern China and southern Japan. A similar investigation to that of the preceding paragraph indicates that the summer rains of these portions of eastern Asia resemble in incidence of intensity, but not in total quantity, the rainfall which is characteristic in areas of similar latitude to the northeast of the United States.

Here, again, the term "monsoon" is applicable to quantities of rain which coincide in period with the onshore winds of the monsoon; and this fact is related to the special nature of the temperature changes to which reference has been made in the first section of this paper.[2]

Summer savanna rainfall.—Summer savanna rainfall in the Sudan and Rhodesia is * * * almost entirely a question of (*a*) a small total annual precipitation and (*b*) a high summer rainfall intensity which is a question of latitude in relation to the force of solar radiation; and apart from the smaller amount of the total annual precipitation summer savanna rainfall is equivalent to "monsoon" rainfall.

[1] *Extracted from* **B. C. Wallis.** Geographical aspects of climatological investigations. Scott. geogr. mag., Edinburgh, July, 1914, **30**: (365, 368–369).

[2] **Wallis, B. C.,** op. cit., p. 356–363.

ON THE USE OF "AVERAGE," "MEAN," "GENERAL."[1]

By HUGH R. MILL, London.

In considering the distribution of rainfall * * * we need to use terms with a definite meaning, and I hope that I may be excused for assigning definite meanings to familiar English words instead of importing classical terms which, despite a grander display of syllables, can mean no more. For convenience I use the term *mean* as indicating the sum of any number of figures divided by that number, reserving the word *average* for the mean of a number of figures representing values in order of time. Thus the mean of 30 annual rainfall values is spoken of as the average rainfall for 30 years. The mean of a number of uniformly distributed figures representing the distribution of rainfall in space I speak of as the *general* rainfall of the area concerned; thus the mean depth of rainfall over England for any day, month, or year is the *general rainfall* of England for that particular day, month, or year. The mean of the general rainfall of England for 30 years is expressed as the *average general rainfall* of England for 30 years. A line passing through points having the same rainfall is an isohyetal line, or *isohyet*—the term having been already introduced is retained on account of its similarity to isotherm and isobar. The line joining successive positions of the center of an atmospheric depression or cyclone is the *track* of the depression. The isohyetal lines representing the distribution of rainfall in a shower may be termed the *splash* of the rainfall, and the isohyets representing the rainfall of one or several days for a considerable stretch of country along the track of a depression, which is the generalization of a succession of splashes, may be called the *smear* of the rainfall of that depression.

[1] *Extracted from* [**H. R. Mill**]. On mapping rainfall. British Rainfall, 1907. London, 1908. **47**: 36–43.
See also **H. R. Mill.** Map studies of rainfall. Quart. jour. Royal metl. soc., London, No. 146, April, 1908, **34**.

TEMPERATURE AND SPRING WHEAT IN THE DAKOTAS.

By THOMAS A. BLAIR, Observer.

[Dated, Weather Bureau, Wagon Wheel Gap, Colo., Jan. 8, 1915.]

In a previous article (1) a short study was made of the relation between rainfall and the yield of wheat in the great northwestern spring-wheat region comprising the States of Minnesota, North Dakota, and South Dakota; and the conclusion reached that the total precipitation of May and June, without regard to its distribution, is, in most years, the most important factor in determining the yield in the two Dakotas, but not in Minnesota. At the same time, attention was called to the fact that there is an evident relation between temperature and yield. A further study of this relation leads me to modify the above conclusion so far as to state that the mean temperature of June exercises an equally important influence on the yield in the Dakotas.

TABLE 1.—*Temperature and wheat yield in the Dakotas, 1891-1913.*

Year.	North Dakota.				South Dakota.			
	Mean temperature, June.	Departure.	Yield.	Departure.	Mean temperature, June.	Departure.	Yield.	Departure.
1891	......	......	......	......	64.2	−2.1	15.2	+4.0
1892	60.5	−2.6	12.2	+0.1	63.9	−2.4	12.5	+1.3
1893	67.4	+4.3	9.6	−2.5	70.3	+4.0	8.5	−2.7
1894	68.8	+5.7	11.8	−0.3	70.6	+4.3	6.6	−4.6
1895	59.7	−3.4	21.0	+8.9	63.7	−2.6	12.0	+0.8
1896	65.6	+2.5	11.8	−0.3	67.0	+0.7	11.2	0.0
1897	61.7	−1.4	10.3	−1.8	65.0	−1.3	8.0	−3.2
1898	62.6	−0.5	14.4	+2.3	67.3	+1.0	12.4	+1.2
1899	62.2	−0.9	12.8	+0.7	66.4	+0.1	10.7	−0.5
1900	66.9	+3.8	4.9	−7.2	69.4	+3.1	6.9	−4.3
1901	61.6	−1.5	13.1	+1.0	66.3	0.0	12.9	+1.7
1902	58.0	−5.1	15.9	+3.8	62.6	−3.7	12.2	+1.0
1903	62.4	−0.7	12.7	+0.6	65.0	−1.3	13.8	+2.6
1904	61.4	−1.7	11.8	−0.3	64.5	−1.8	9.6	−1.6
1905	59.7	−3.4	14.0	+1.9	64.4	−1.9	13.7	+2.5
1906	62.0	−1.1	13.0	+0.9	63.9	−2.4	13.4	+2.2
1907	61.9	−1.2	10.0	−2.1	64.2	−2.1	11.2	0.0
1908	60.4	−2.7	11.6	−0.5	63.7	−2.6	12.8	+1.6
1909	62.9	−0.2	13.7	+1.6	66.9	+0.6	14.1	+2.9
1910	67.3	+4.2	5.5	−6.6	68.3	+2.0	12.8	+1.6
1911	66.9	+3.8	8.0	−4.1	73.4	+7.1	4.0	−7.2
1912	61.8	−1.3	18.0	+5.9	64.8	−1.5	14.2	+3.0
1913	65.8	+2.7	10.5	−1.6	69.6	+3.3	9.0	−2.2
Average	63.1	......	12.1	......	66.3	......	11.2	......

It is well known that cool and wet weather best promotes the development of wheat until the time of heading, after which more sun and less rain are needed (2), (3). As wheat is seeded during April in these States, the spring type of weather should be prolonged through June for the best results. But June is sometimes a very hot month in the Dakotas; it may even bring the highest temperatures of the year, and the mean may exceed the normal for July, which is ordinarily the warmest month. It is to be expected, then, that these hot Junes should have a marked deleterious effect on the wheat yield, and the following table and charts are intended to exemplify this effect.

In North Dakota, out of the 22 years studied, only 4 show departures of the same sign, and in each case one or both of the departures is small. The correlation coefficient, as calculated from this table, is −0.67, with a possible error of 0.08, evidence of a well-defined inverse relation between temperature and yield. A similar comparison in my previous article, between yield and combined precipitation of May and June gave 5 years with departures of unlike sign and a positive coefficient of 0.63, with a possible error of 0.05. Referring to the chart showing combined effect of temperature and precipitation, we notice that the yield has never been above normal when the temperature was above normal, but has three times been above when the precipitation was below. On the other hand, it has only four times been less than normal when the temperature was less and an equal number of times when the precipitation was greater. Similar comparisons, using the mean temperatures for May and July instead of June, show no such correlations. For May there are 10 years with departures of the same sign, and the correlation coefficient is +0.02; for July 8 years and a coefficient of −0.19. Evidently June is the critical month in the influence of temperature upon yield, and that influence is very marked, being of about the same importance as the combined May and June rainfall.

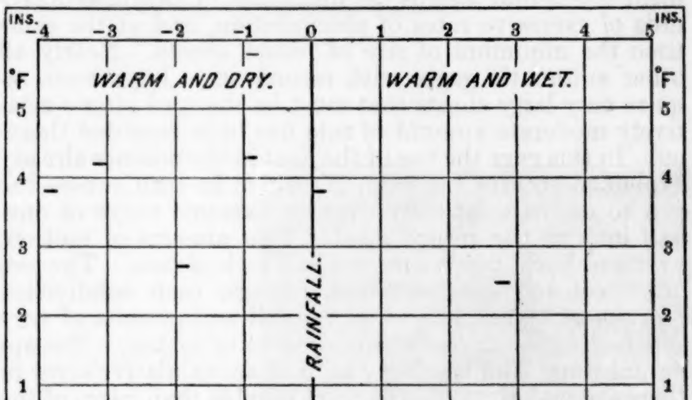

FIG. 1.—Chart showing the combined effect of temperature and rainfall upon the wheat yield of North Dakota. Rainfall departures are from the averages for May and June; temperature departures are from the average for June. Yield is above (+) or below (−) the average.

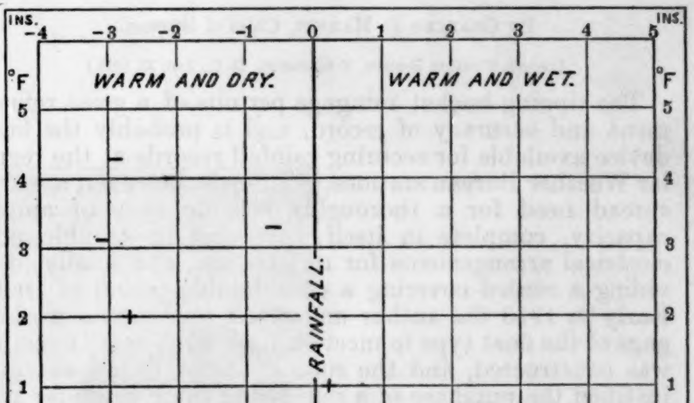

FIG. 2.—Chart showing the combined effect of temperature and rainfall upon the wheat yield of South Dakota. Rainfall departures are from the averages for May and June; temperature departures are from the average for June. Yield is above (+) or below (−) the average.

In South Dakota 5 of the 23 years have departures of like sign; but in this case also the departures are small, and the correlation coefficient is greater than in North Dakota, being −0.73, with a possible error of 0.07. The coefficient expressing the relation between precipitation and yield was previously found to be 0.59, and the possible error 0.06. Of the 5 years with departures of like sign, 3 are with temperature and yield both above normal and 2 with both below. Likewise there are 5 years when precipitation and yield fail to show their expected relation, 1 wet year with a small yield, and 4 dry years with high yields. In this State, also, May and July temperatures are apparently without significance in this connection. In both States the cool and wet years are undoubtedly the most favorable, but in South Dakota the greatest yield was in a cool and dry year. On the whole, the cool and dry years appear somewhat more favorable than warm and wet years, but the number of observations of these conditions is rather limited. Similar tables for Minnesota gave small coefficients and indicated no definite correlation.

Considering only calendar months, the rainfall of May and June and the mean temperature of June are the important weather factors, and they are of about equal importance, affecting the wheat crop of the Dakotas.

REFERENCES.

(1) MONTHLY WEATHER REVIEW, October, 1913, **41:** 1515–1517.
(2) **Abbe, C.** First Report on Climate and Crops (Weather Bureau Bulletin **36**), p. 316.
(3) **Hunt.** The Cereals in America.

AN EIGHT-DAY MECHANICALLY RECORDING RAINGAGE.[1]

By CHARLES F. MARVIN, Chief of Bureau.

[Dated, Weather Bureau, Washington, D. C., Jan. 23, 1915.]

The tipping-bucket raingage permits of a great refinement and accuracy of record, and is probably the best device available for securing rainfall records at the regular Weather Bureau stations. There is, however, a widespread need for a thoroughly reliable gage of ample capacity, complete in itself, involving no troublesome electrical arrangements for registration, and finally providing a record covering a considerable period of time. Early in 1913 the author undertook to design a weekly gage of the float type to meet such requirements; a model was constructed, and the success of the tests has since justified the purchase of a number of these gages for use in the Weather Bureau service. They will find an extended use in the studies of rainfall in connection with many projects wherein the *rate* of rainfall is an important factor.

Wind shields of the Nipher type are provided, which we hope will assist in obtaining the true catch even on occasions when the wind velocity is considerable.

Description.—The photograph reproduced in figure 1 shows the complete gage. The circular collector, *A*, is exactly 8 inches inside diameter across its sharpened (beveled) brass rim, and is surrounded by the rectangular wind shield, *B*. This shield is nearly 21 inches square at its upper edge and curves downward and inward to the copper cover, *C*, to which it is screwed. The cover is about 15 inches square inside and supports the 8-inch collector, the two together forming the top. The cover is ordinarily hinged to the top plate of the support, *E*, and is locked in position by a small bolt. The support, *E*, which is a little over 2 feet high, is made up of two iron castings; the upper casting carries the recording apparatus and the top, and the lower one forms the base for the receiver, *D*. The two castings are connected at the center by a $1\frac{1}{4}$-inch pipe, which also serves to inclose a small brass counterweight. The posts of the support, *E*, are four small iron pipes, which are screwed into the upper casting at its corners and fastened to the lower casting by means of set screws. The lower ends of the corner posts form feet for the gage.

Figures 2 and 3 illustrate the recording apparatus in detail. The registration is a record of the motion of a float upon the surface of the water in the receiver, *D*. To eliminate inaccuracies and uncertainties, the float is suspended by means of a fine flexible brass chain, such as jewelers use, permanently attached to one end of the drum, *H*. When the float rises, the chain is wound up by the pull of the counterweight suspended from a length of silk cord, also fastened to and wound up on the drum, *H*. The chain and cord run in a shallow screw thread cut in the drum, the chain winding up as the cord unwinds, and vice versa. The chain eliminates possibilities of variation of length, such as would be caused by moisture and stretching should a cord be used, and its permanent attachment to the drum, *H*, makes slipping impossible.

The cam shaft, *I*, carrying the drum, *H*, turns once for each one-half inch of rainfall and revolves a cylindrical cam, *K*, made to turn with the shaft, *I*, but free to slide endwise at the same time. The pen and pen lever are shown at *S* and *L*, respectively. The pen carrier, *T*, is mounted on the long screw, *N*, and guided by the rod, *U*. The motion of the pen is somewhat complex, but the arrangement is one that affords the maximum of clearness of records of excessive rates of precipitation, and at the same time the minimum of size of record sheets. Nearly all other automatic gages with records on a large scale require very large sheets that must be changed after a relatively moderate amount of rain has been recorded thereon. In this gage the rise of the float in the manner already explained rotates the cam, *K*, which in turn causes the pen to oscillate laterally over an extreme range of one-half inch on the record sheet. This amount of motion, over and back, represents one-half inch of rain. The record sheet has one-tenth-inch rulings, each subdivision represents 0.05 of an inch of rainfall and permits of very satisfactory estimates to hundredths of inches. The apparent impossibility of any kind of accumulative error in this gage makes its records more reliable than gages of the tipping-bucket type.

The adoption of an oscillating motion for the pen permits a large amount of precipitation to be recorded in a narrow band one-half inch wide across the record sheet. The remainder of the sheet is made available for additional record simply by causing the pen carrier to move laterally by the action of the clock, at the rate of one-half inch per revolution of the drum. Thus each day's record (one revolution of the drum) occupies only a transverse space on the record sheet one-half inch wide. Each sheet provides a record for eight days. The reason for adopting an 8-day record is that four sheets will suffice for a full record for each and every month. Instruments using only 7-day or weekly record sheets require five sheets for a month's record with only little on one of the sheets. The record cylinder, *F*, is 6 inches in diameter outside, and $5\frac{7}{16}$ inches in length over all, and it is made to revolve on the axle, *R*, by a clock which is entirely

[1] *See* Weather Bureau Instrument Division Circular E, 3d ed., App. 2. Washington, 1915.

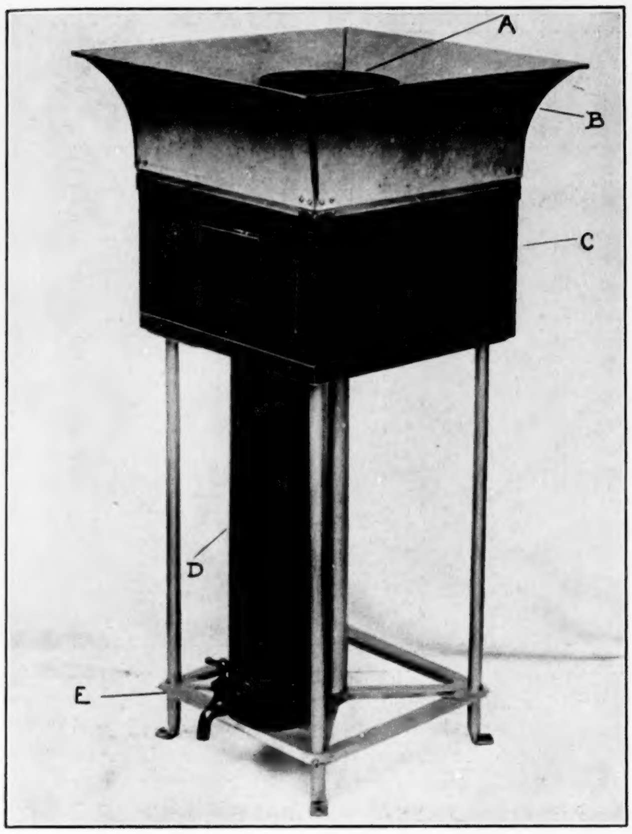

FIG. 1.—Marvin 8-day recording raingage, complete.

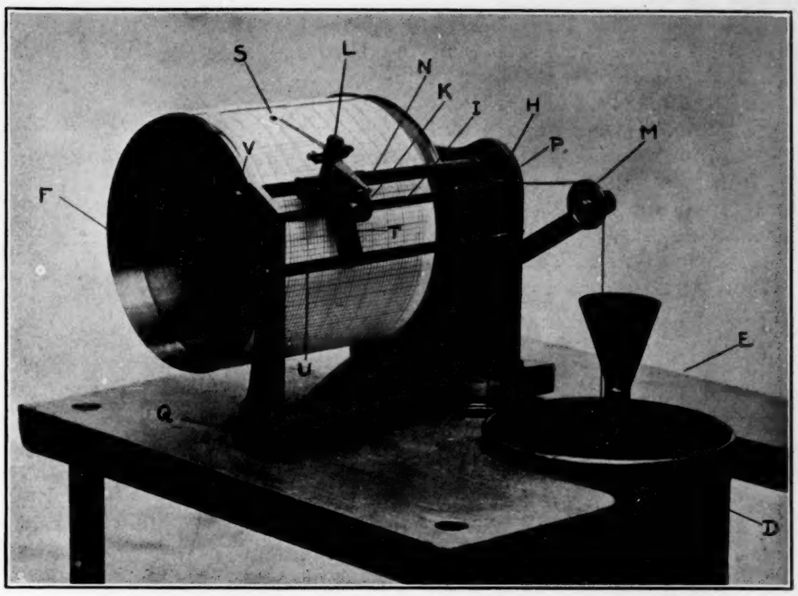

Fig. 2.—Recording mechanism of Marvin recording raingage, showing pen in position on sheet.

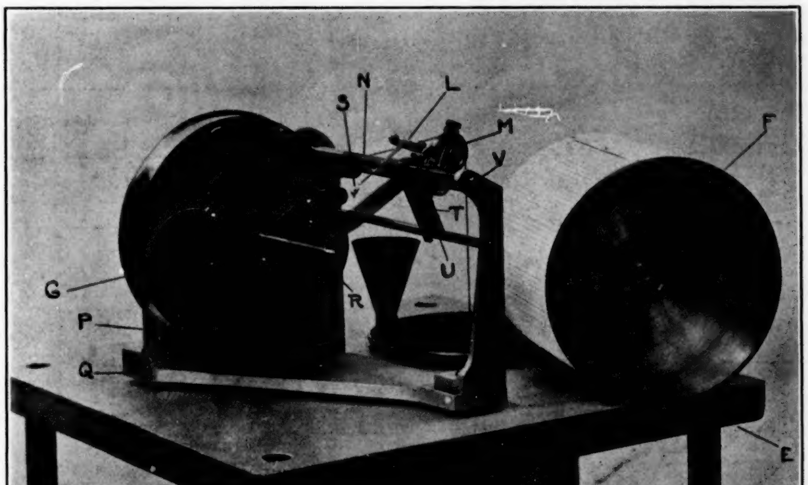

FIG. 3.—Recording mechanism of Marvin raingage with the record cylinder removed and showing clock.

inclosed and protected from dust and moisture when the cylinder is in place.

Operation.—The rainfall caught in the 8-inch collector (*A*, fig. 1) passes through a funnel and a small pipe as shown in figure 2, to the bottom of the cylindrical receiver, *D*, which has half the sectional area of the receiver, *A*. The depth of rainfall is therefore only doubled for measurement. Receiver *D* has a capacity for nearly 10 inches of rainfall, and may be conveniently emptied by the aid of the spigot provided. This has a siphonlike extension, inside the receiver, that permits the surplus water within to be drawn off to a certain zero level, but leaves remaining not only a small quantity of water but especially a surface layer of kerosene that is added to the receiver when the instrument is installed for the purpose of preventing evaporation. Changes in the level of the water are communicated through a float and auxiliary mechanism to the recording pen in the manner explained above.

Although the gage may be continued in operation for eight days without requiring attention, yet occasional inspections during the period will avoid possible failure, as it can not be expected that the instrument will invariably give satisfactory service without attention.

Explanation of record.—Figure 4 shows a record sheet, the actual size of which is about 20 by 5¼ inches over all when trimmed at the right-hand end ready to be placed on the cylinder. The vertical graduations on the sheet are spaced nearly 0.13 of an inch apart and correspond to 10 minutes of time; and the diagonal lines are spaced 0.10 of an inch apart and correspond to 0.05 of an inch of rainfall.

The graduations are of such size as to permit the record to be easily read, as will be seen by examining the illustration, figure 4. Take for example the rainfall recorded during the night of August 28, 1914. It will be noticed that "rain began" (RB) at 7:18 p. m., but from that time until 8:47 p. m. very little rain fell, as is evidenced by the line traced by the pen, which is very nearly parallel to the diagonal lines but which still has an upward tendency. A trace (T), or an amount too small to measure, is therefore entered for the hour ending at 8 p. m. At 8:47 p. m., however, the record line makes a decided bend upward, passes across four-fifths of the space in which it is moving (amounting to 0.04 of an inch of rainfall), and thence across two additional diagonal lines; all of which totals to 0.14 of an inch of rain up to the point where the record line crosses the vertical 9 o'clock line. Between 9 and 10 o'clock the pen made four complete oscillations with an additional movement of slightly more than two divisions (corresponding to 0.11 inch), making a total of 1.11 inches for the hour. During the next hour another heavy downpour occurred, the gage recording 1.12 inches within 32 minutes, after which time until 11:05 p. m. no appreciable amount fell. The storm terminated with an additional heavy fall amounting to 0.27 of an inch within a short period ending at 11:10 p. m., the rain finally ceasing altogether at 12:40 a. m. (RE), after recording 0.01 of an inch between 12:20 and 12:22 a. m. The total amount of rainfall for the entire storm is therefore 2.65 inches. The performance of the gage in recording lighter rains is shown by the record for the period from 4:04 p. m., August 25, to 8:55 a. m., August 26.

The observer should be careful to record the times of beginning and ending of rain by eye observations, making a written memorandum of the actual time of occurrence to be transferred to the record sheet when removed from

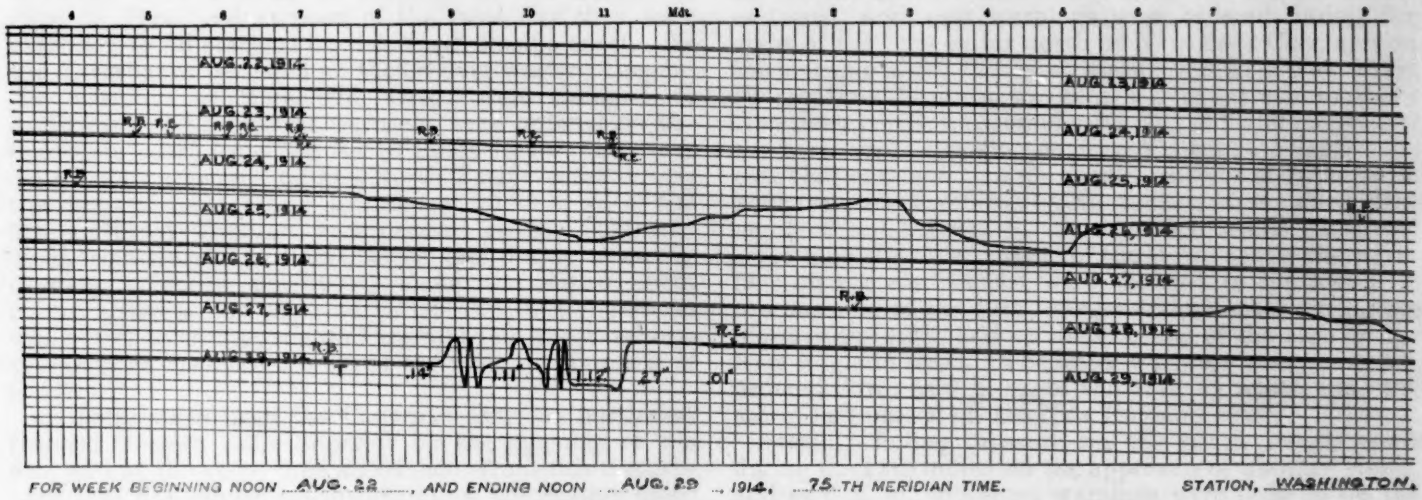

FIG. 4.—Sample of portion of record sheet from Marvin recording raingage. Record reduced to about one-half size and showing actual record obtained at the Weather Bureau, Washington, D. C. *RE*, rain began; *RE*, rain ended.

the cylinder. The beginning of rain should be indicated by the letters "RB" (rain began), the ending by "RE" (rain ended), and the actual time checked on the sheet.

Insuring good record.—After operation of the gage has begun, there are several features to be considered in order that a good and continuous record may be insured, as follows:

1. The clock should be kept running to the exact time, as nearly as can be ascertained, and if adjustment becomes necessary, it will be accomplished in the usual manner by moving the small rod passing through the slot in the mounting plate, *P*, to the side marked *S* or *F*, to cause the clock to go slower or faster, respectively. If there is a time error, it should be noted on the record sheet when it is removed and the corrections applied to the several beginnings and endings of rain.

2. If, for any reason, the pen has not made a complete record the total amount may be determined by noting the number of lateral throws made by the pen while the water is being drawn out to its original or zero level, preparatory to placing a new record sheet on the cylinder. The amount thus determined should be indicated on the sheet together with a brief note of explanation giving the times of occurrence of rainfall if practicable.

3. To avoid needless friction about every second week, and oftener in a dirty location, the horizontal bars and screws, *I*, *U*, and *N* should be rubbed off with an oily rag so that there remains a clean but *slightly* oiled surface over which the pen carriage slides. The long screw with the pin and carrier can easily be removed by backing off the pivot screw, *V*, and all other parts should be thoroughly cleaned by use of kerosene or similar light oil. When cleaned these parts should be supplied with only the merest film of fine oil, and when replaced the pivot screw, *V*, should be set up so that there will be just a trifle of "end shake" to the screw, *N*. Occasionally the pivot bearings in the mounting plate and post should be given a *little* clock oil. The clock being inclosed should need but little attention and will be cared for in the customary manner.

4. Under no circumstances will the gage be left out in freezing weather, for if ice forms in the receiver or in the pipe leading thereto these parts are likely to be rendered unserviceable.

NEW METEOROLOGICAL STATIONS IN KOREA.

RAYMOND S. CURTICE, Vice and Deputy Consul General.

[Dated Seoul, Chosen, Jan. 21, 1915.]

It is reported that the authorities concerned have decided to establish during the fiscal year ending March 31, 1916, two meteorological stations and 25 meteorological offices for taking observations throughout Chosen. The plans of the authorities also include an increase of 25 offices during each fiscal year for the four years thereafter.

SECTION III.—FORECASTS.

STORMS AND WARNINGS FOR JANUARY, 1915.

By H. C. FRANKENFIELD, Professor and District Forecaster.

[Dated, Weather Bureau, Washington, D. C., Feb. 20, 1915.]

WIND STORMS.

On the morning of January 1 a northwestern disturbance was centered over western Lake Superior attended by snows, and advisory warnings of fresh to strong west to northwest winds were sent to open ports on Lake Michigan, and during the day and night the winds occurred as forecast. On the morning of the 2d, as pressure was falling off the North Pacific coast, southeast storm warnings were ordered at stations on the Straits of Juan de Fuca, and at noon of the same day they were extended to all stations on the North Pacific coast. As the disturbance persisted on the 3d over western Oregon, the warnings at Marshfield, Oreg., were changed to southwest, and southeast warnings were ordered on the California coast from Eureka to Point Reyes. Another disturbance appeared off the North Pacific coast during the night of the 4th and 5th, and at 10:30 a. m. of the 5th southeast warnings were ordered on the California coast from Eureka to Point Reyes, and during the early evening extended northward along the entire north coast. High winds occurred as forecast, but the storm was not of long duration and warnings on the Washington-Oregon coast were lowered early on the morning of the 6th.

A disturbance from the Canadian extreme northwest reached western Lake Superior by the morning of the 6th, and at the same time an offshoot from this disturbance that had moved southward along the eastern slope of the Rocky Mountains had reached Missouri. By the evening of the 6th there was a single storm center over lower Michigan with pronounced development and advisory messages for strong west to northwest winds were sent to lake ports. At the same time southwest storm warnings were ordered along the Atlantic coast from Wilmington, N. C., to Bangor, Me. The storm moved northeastward with increasing intensity and winds on Lake Michigan and the Atlantic coast occurred as forecast, New York City reporting a velocity of 64 miles an hour from the southeast during the night of the 6th–7th. On the morning of the 7th warnings were extended on the Maine coast east of Bangor, and at the same time they were ordered down from Wilmington to Fort Monroe. By this time another disturbance had appeared off the north Pacific coast and early in the evening southeast and southwest warnings were displayed from Point Reyes northward, but only at stations along the immediate coast. Only moderately strong winds attended this storm.

During the next three days there were no disturbances of consequence. A moderate depression that first appeared over southeast Colorado on the morning of the 9th moved southeastward to Oklahoma during the ensuing 24 hours, and small craft warnings were ordered on the Gulf coast from Pensacola to Carrabelle, Fla. At this time the fourth north Pacific disturbance of the month was approaching the coast, and during the day and evening southeast warnings were ordered at all stations on the north coast. Fresh southerly gales attended this storm and during the 11th they extended southward to the north California coast, warnings having been previously ordered as far south as San Francisco. By the morning of the 11th the Oklahoma disturbance had reached the mouth of the Mississippi River and, because of a strong high area over the north Atlantic States, northeast storm warnings were ordered at 10:30 a. m. from Tybee Island, Ga., to Fort Monroe. At 2:30 p. m. southeast warnings were also ordered at Jacksonville and on the Gulf coast from Cedar Keys to Punta Rasa, Fla. As the disturbance had now turned toward the northeastward, northeast warnings were ordered during the night of the 11th as far north as New York City, and on the morning of the 12th at all stations north of New York. By this time the storm was central over extreme southern New Jersey with a barometer reading of 28.90 inches and the high winds resulting covered the entire Atlantic and east Gulf coasts with a maximum velocity of 76 miles an hour from the northeast at Nantucket, Mass., during the night of the 12th–13th. As the high winds continued some time after the passage of the storm center the warnings on the south coast were changed to southwest on the morning of the 12th, on the middle coast during the night of the 12th, and on the morning of the 13th on the New England coast. The latter warnings were, however, ordered down at 9 p. m. of the 13th by which time the storm had passed off the New England coast.

Steadily falling pressure on the north Pacific coast during the 12th indicated the approach of another storm, and at 6 p. m. southeast warnings were ordered on the California coast from San Francisco to Eureka, and at 6:15 p. m. southeast and southwest warnings were ordered for Marshfield, Oreg., the mouth of the Columbia River, and the Straits of Juan de Fuca. On the morning of the 13th the storm was more definitely developed and warnings were ordered for the balance of the north Pacific coast. Southeast to south gales attended this storm with a maximum velocity of 60 miles an hour from the southeast at North Head, Wash.

On the evening of the 14th pressure was low throughout the West with three or four separate centers of disturbance. By the evening of the 15th there was a principal disturbance of marked character over north central Texas and a secondary over southeast Colorado. As pressure had been falling rapidly over the Southwestern States during the 15th, southeast storm warnings were ordered at 4 p.m. from Brownsville to Galveston, Tex., and at 10:30 p. m. were extended eastward to Apalachicola, Fla. The disturbance turned to the northeastward after reaching north central Texas, leaving a secondary near the mouth of the Rio Grande and strong southeast to south winds occurred on the Gulf coast. The principal disturbance continued north-northeastward and at 8 p. m. of the 16th was central over northern Iowa, with a barometer reading of 29.34 inches. Twelve hours earlier advisory notices of east to north gales had been sent to open ports on Lake Michigan and they were repeated at 10 p. m. with notices

of change in direction to west and northwest. At the same time, owing to the marked pressure gradient, southwest storm warnings were ordered on the Atlantic coast from New York City to Norfolk, Va. The resulting winds, however, during the next 24 hours were only fresh. The secondary disturbance that was near the mouth of the Rio Grande on the morning of the 16th now moved northeastward with increasing intensity and by the night of the 17th had reached extreme southern Mississippi. Southeast storm warnings were now ordered on the Atlantic coast from Jacksonville to Morehead City, N. C., and northeast warnings farther northward to Fort Monroe, Va. By the morning of the 18th the disturbance extended in trough shape from the east Gulf States to Virginia and southeast warnings were ordered from Baltimore to Boston. At 8 p. m. of the 18th the disturbance had become more localized and was central over southwestern Virginia with increased intensity; the warnings from Hatteras, N. C., to Fort Monroe were now changed to northwest, and southwest warnings were ordered north of Boston. Strong winds occurred during the passage of this storm, but no severe gales, New York City reporting a velocity of 52 miles from the south during the 18th (the highest velocity reported for this storm).

From the 18th to the 20th, inclusive, a disturbance of quite marked character moved southeastward from Saskatchewan to the middle Mississippi Valley and thence passed eastward off the Atlantic coast. This disturbance was quite well-defined so far as barometer readings were concerned, but owing to the prevailing low pressure on all sides no high winds occurred and no storm warnings were ordered.

During the 20th a disturbance developed along the eastern slope of the central Rocky Mountains and by the evening of the 21st it covered west Texas, with a strong and cold high area to the northward. Advisory warnings for increasing north and northeast winds were at once issued for open ports on Lake Michigan, but the winds that followed were only moderate, although accompanied by snow in substantial quantity. The Texas disturbance reached western Arkansas by the morning of the 22d, and small craft warnings were ordered from Pensacola to Carrabelle, Fla. As pressure over the west Gulf States continued to fall, southeast storm warnings were ordered at 1:10 p. m. for the New Orleans section and at 2:45 p. m. from Mobile, Ala., to Carrabelle, Fla., with instructions to change to northwest at sunset. At 3 p. m. northwest warnings were also ordered for the Louisiana and Texas coasts. By the night of the 22d the disturbance had reached Indiana and at 10:30 p. m. southeast warnings were ordered from New York northward, except on the Maine coast, where northeast warnings were ordered displayed. Strong northerly winds occurred during the night of the 22–23d on the west Gulf coast and strong southerly winds on the north Atlantic coast during the 23d. On the morning of the 23d a secondary disturbance from the mouth of the Rio Grande had reached the middle Gulf coast and the warnings in that section were therefore changed to northwest at 11 a. m. On the morning of the 24th this Gulf disturbance was central over southwest Georgia with a strong high area to the northward indicating the probability of strong northeast winds on the coast, and at 10 a. m. northeast warnings were ordered from Charleston to Boston. At 10:30 p. m. the warnings were extended to all stations north of Boston, and strong shifting winds and gales prevailed quite generally over the districts where warnings had been ordered. On the morning of the 25th the storm was central over southern New Jersey. Warnings were still displayed north of Boston and they were ordered continued from New London, Conn., to Boston. The storm passed to the northeastward of Maine during the night of the 25th.

After a respite of 11 days a disturbance appeared off the California coast on the morning of the 24th and southeast storm warnings were ordered from Eureka to Point Reyes. The disturbance was not of severe character and no high winds were reported. On the evening of the 26th there were indications of the approach of another disturbance toward the north California coast and on the morning of the 27th southeast warnings were again ordered from Eureka to Point Reyes. This storm increased considerably in intensity during the next 12 hours and at 6:40 p. m. southeast warnings were extended northward to Marshfield, Oreg. As pressure was still falling on the morning of the 28th the warnings were continued from Eureka to Point Reyes and a few hours later were extended southward to San Francisco and continued northward to Marshfield. By the morning of the 29th pressure was very low on the Pacific coast with a barometer reading of 29.14 inches at Eureka, Cal., and southeast warnings were therefore hoisted at all other points on the Pacific coast. High winds occurred along the entire coast during the 28th and 29th and on the 30th the disturbance decreased considerably in intensity.

On the morning of the 28th pressure was falling in the Atlantic States and continued to fall rapidly during the day over new England. There were some indications of strong northeasterly winds and northeast storm warnings were ordered at 4:30 p. m. from Block Island to Eastport. By evening, however, the threatening conditions had disappeared and the warnings were lowered at 9 p. m. The next disturbance noted appeared on the morning of the 30th over southeast Idaho and the adjacent States, probably an offshoot from the extensive Pacific coast storm. It appeared to be developing eastward and southeastward and small craft warnings were ordered on the Gulf coast from Brownsville, Tex., to Carrabelle, Fla., for the strong winds that occurred during the 30th. By the evening of the 30th the storm was central over the southwestern States with somewhat increased intensity and advisory warnings of strong easterly winds with snow were sent to open ports on Lake Michigan. By the morning of the 31st the storm was over Oklahoma with strong high pressure to the northeastward and southeast warnings were ordered from Galveston to Carrabelle, Fla. During the afternoon they were extended on the Gulf coast as far as Tampa and also ordered on the Atlantic coast from Jacksonville to New York. Strong winds and gales prevailed on the Gulf coast, but on the Atlantic coast the winds were only moderately strong owing to the slow movement of the storm which by the night of the 31st had moved only to Missouri, thereby necessitating additional advices to open ports on Lake Michigan of strong northeast to north winds with snow.

As pressure was again falling on the north Pacific coast on the morning of the 31st southeast storm warnings were ordered from San Francisco to Eureka and early in the evening extended northward as far as the Straits of Juan de Fuca.

COLD WAVE AND FROST WARNINGS.

On the morning of the 2d a disturbance was central over Ontario attended by quite high temperatures and cold wave warnings were therefore ordered for the southern upper Lake and western lower Lake region and the

upper Ohio Valley. A moderate cold wave occurred over the districts indicated on the following day. As the high pressure following this Ontario disturbance extended southward to the Gulf, frost warnings were also ordered on the morning of the 2d for Alabama, Mississippi, Georgia, and interior Florida, but owing to the prevalence of cloudy weather the warnings were not generally successful. By the evening of the 2d the Ontario disturbance had passed off the New England coast and cold-wave warnings were therefore ordered for New York and the greater portion of New England. These warnings also failed of verification, except in a few places, on account of the slow rate of fall, although the temperatures were sufficiently low.

Following the eastward movement of the Rocky Mountain disturbance on the 5th and 6th frost warnings were ordered for interior Louisiana and southeast Texas and warnings of freezing temperature for northeast Texas. These warnings were fully justified by the occurrence of frost on the morning of the 7th as forecast. Similar forecasts for the 8th, however, failed of verification owing to cloudy weather caused by a moderate disturbance near the mouth of the Rio Grande. Following the Pacific coast storm of the 6th to the 8th there was a rapid rise in pressure and on the morning of the 9th warnings were issued for severe frost in California. Heavy frost occurred on the morning of the 10th in portions of northern California.

A disturbance that was over Oklahoma on the morning of the 10th was followed by a strong and moderately cold high-pressure area and frost warnings were therefore ordered for the west Gulf States with excellent verification. On the morning of the 12th frost warnings were extended to the East Gulf States, including northern Florida, and again on the 13th in Georgia and north Florida. In both instances frost occurred as forecast. On the morning of the 12th warnings of heavy frost were also issued for northern California, but the persistence of the storm conditions caused a failure of the forecast. On the morning of the 15th and 16th conditions were more stable and warnings of heavy frost for California were followed by quite general verification, except over the extreme southern portions. On the morning of the 16th the rapid north-northeastward movement of the storm that was then over western Missouri, combined with the high area to the northwestward, indicated the approach of colder weather and cold-wave warnings were therefore issued for the lower Missouri and upper Mississippi Valleys. The further inclination of the storm track toward the northward disturbed the existing conditions and the subsequent fall in temperature was not sufficient to justify the warning, although the 24-hour fall in temperature amounted to as much as 40° in portions of east Kansas and west Missouri. Cold-wave warnings were also ordered on the morning of the 16th for interior east Texas, northern Louisiana, Arkansas, and extreme eastern Oklahoma. These also failed of verification, although the fall in temperature ranged from 16° to 28° and the line of freezing temperature extended well into central Texas. On the morning of the 17th the passing of a secondary disturbance over the middle Gulf coast indicated the necessity of further frost and cold-wave warnings in the South and they were therefore ordered generally throughout the Gulf States, except eastern and southern Florida. Cold-wave warnings were also ordered at the same time for central Tennessee southern Kentucky and the central and eastern portions of lower Michigan. The warnings in the South failed utterly, except in Texas, owing to the northward development of the disturbance. Cold-wave warnings for the States to the northward also failed, although there was a considerable fall in temperature accompanied by snow.

Frost warnings were also issued for California on the morning of the 17th and again on the 18th, 19th and 23d, those of the latter date failing of verification on account of rain. On the morning of the 19th frost warnings were issued for Louisiana and southeast Texas, but failed of general verification on account of falling pressure to the northward; warnings were repeated on the 20th for Louisiana, but for a similar reason no frosts were reported. By the night of the 21st, however, the disturbance over Texas and the cold high area to the northward indicated an early and decided change in temperature conditions. Cold-wave warnings were ordered for the entire state of Texas, except the extreme south and extreme west portions; also for northwest Louisiana, Oklahoma, Arkansas, north and west Mississippi, eastern Kansas, eastern and southern Missouri and extreme southern Illinois. These warnings were repeated on the morning of the 22d and during the evening of the 22d were extended so as to cover entire Ohio Valley. The cold wave that followed was quite extensive although not very severe, except in portions of the Dakotas and Nebraska, and on the morning of the 23d it covered the Plains States and the Great Central Valleys, except the upper Ohio.

During the 23d cold wave and freezing temperature warnings were continued for the west Gulf States, and on the evening of the 23d cold-wave warnings were ordered for the Atlantic States, except Florida, as it appeared at that time that the southern disturbance would pass off the Florida coast. Instead, however, it drifted slowly northward so that the cold weather did not extend farther south than South Carolina nor did it reach the north Atlantic coast, although, of course, temperatures fell decidedly. Cold-wave warnings were also ordered on the morning of the 24th for western South Dakota and eastern Wyoming, as pressure was then low over Wyoming with a reenforced cold high area coming down from the north. This warning was very timely as the temperature at Sheridan, Wyo., on the morning of the 25th was $-20°$. On the evening of the 24th cold-wave warnings were extended to east Colorado, Kansas, and the lower Missouri Valley, but without verification, except over a very limited area. On the morning of the 25th warnings of frost and freezing temperature were again sent to Texas and Louisiana, but cloudy weather with low pressure to the northward caused the temperature to rise. On the evening of the 26th a very cold high-pressure area was central over the Canadian Northwest. Low temperature had prevailed for several days over the northwestern States and no further warning was necessary, but warnings were ordered for east Colorado, western and southern Wyoming, eastern and southern Iowa and the interior of northern Illinois, and during the 27th they were extended generally over the Lake region, the Central Valleys, New England and the Middle Atlantic States. This cold wave proved to be the most pronounced and extensive one of the present winter and temperatures as low as zero occurred almost to the Ohio River. By the morning of the 29th the cold wave had passed, except in New England, and no more cold weather occurred by the end of the month.

SPECIAL WARNINGS.

On the evening of the 21st warnings of snow with strong northerly winds were sent to the Texas Panhandle and also heavy snow warnings to northern and central Oklahoma, southeast Kansas, Missouri, and the lower Ohio Valley. Heavy snow and sleet occurred as forecast, and on the morning of the 22d heavy snow warnings were also sent to Missouri, northern and central Illinois, and western New York, and were followed by heavy snow over those sections except Missouri. A warning of heavy snow for the Middle Atlantic States and southern New England that was sent on the 24th was generally successful for New England and New York, but not for the States to the southward, as the southern disturbance upon which the forecast was based divided by the morning of the 25th into two sections, causing rain over New Jersey and southeast Pennsylvania, while the western section of the storm caused the heavy snow to extend into the lower Lake region and the upper Ohio Valley.

METEOROLOGICAL RADIOTELEGRAMS TO MARINERS FROM SCHEVENINGEN.

This bureau has received the following communication[1] through the legation of the Netherlands and the United States Department of State, and publishes here an English translation for the benefit of its marine observers and mariners generally.

THE HAGUE, *June 10, 1914*.

On and after July 1 next the station of Scheveningen Harbor will send at 11:15 a. m. and p. m. (Greenwich time) a meteorological radiotelegram in Dutch and French, followed by a storm signal whenever necessary, and also a notice to mariners in Dutch and English.

The meteorological radiotelegram will be preceded by the letters K.N.M.I. and will consist of four sets of 2 groups of 5 figures each for the stations Helder, Flushing, Gris Nez, and The Hague; and, further, of four sets of two groups wherein one group will have 5 and the other group will have 4 figures each for the stations Yarmouth, Shields, Skudnaes, and Sylt, according to the scheme BBBWW SHTT(G). In this scheme BBB stand for the atmospheric pressure in tenths of a millimeter, omitting the 700, WW indicate the direction, and S the force of the wind; H gives the condition of sky and weather; TT the temperature in centigrade degrees, 50 being added to temperatures below 0° C.; G indicates the condition of the sea, all being according to the scales given below.

Following the above will come, if deemed important, first, the storm signal, e. g., warning signal, signal of shifting southeast storm; second, the Notice to Mariners preceded by the letters N.B.A.Z., e. g., wreck, mouth Hook of Holland.

The scales according to which the above information is reported are as follows:

Wind.				Condition of sky and weather.		Condition of sea.	
Direction.		Force.					
WW	Significance.	S	Significance.	H	Significance.	G	Significance.
00	Calm	0	Calm	0	Clear	0	Smooth.
02	NNE., etc	1	Almost calm	1	Slightly cloudy ($\frac{1}{4}$).	1	Very fine.
06	ENE., etc	2	Very light	2	Cloudy ($\frac{1}{2}$)	2	Fine.
08	East, etc	3	Light	3	Very cloudy($\frac{3}{4}$).	3	Slightly rough.
12	SE., etc	4	Moderate	4	Wholly overcast.	4	Rough.
16	South, etc	5	Rather high	5	Rain	5	Swell.
20	SW., etc	6	High	6	Snow	6	Heavy swell.
24	West, etc	7	Very high	7	Mist	7	Heavy sea.
28	NW., etc	8	Violent	8	Fog	8	Very heavy.
32	North, etc	9	Storm	9	Storm	9	Violent.

Every observation that is missing for each station is replaced by an appropriate number of x's.

Examples of meteorological radiotelegrams from the first and the fifth of the eight sets of two groups K.M.N.I. are 69010–21541 and 57316–4405; their translations follow:

HELDER.	YARMOUTH.
Barometer, 769.0 mm.	Barometer, 757.3 mm.
Wind direction, ESE.	Wind direction, south.
Wind force, very light.	Wind force, moderate.
Sky, slightly cloudy.	Sky, overcast.
Temperature, 4°C.	Temperature, 5°C.
Sea, very fine.	

[1] [Netherlands]. Afdeeling Hydrographie van het Ministerie van Marine. Bericht an zeevarenden, No. 129. 's-Gravenhage, 10 Juni 1914.

SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS, JANUARY, 1915.

By ALFRED J. HENRY, Professor of Meteorology, in charge of River and Flood Division.

[Dated: Washington, D. C., Mar. 3, 1915.]

Georgia and the Carolinas.—There were three periods, each exceeding 24 hours, of steady, but not especially heavy rainfall, over the South Atlantic States during the month. The first period occurred between the 5th and the 7th, although the great part of the rain fell on the 6th. The second period occurred on the 12th to 13th and was the shortest of the three. Had the rivers been at a lower stage in the beginning it is doubtful whether flood stages would have been reached. The third period included the 17th and 18th, with the heaviest rain in Georgia on the 17th. This latter period was one of very general rains continuing practically 48 hours over Georgia and the Carolinas.

As a result of the rains the rivers were at relatively high stages throughout the month, with flood or freshet stages about the 8th, 13th, 19th, and other dates.

Alabama.—The Tennessee River in northern Alabama was above the flood stage on the 1st and 2d, but no damage resulted. The lower Tombigbee of Alabama was above the flood stage at Demopolis, Ala., on the 3d and again on the 24th and 25th. About 15 square miles of bottom land was overflowed.

Virginia, Maryland, and Pennsylvania.—The rain period of the 5th to 7th, as mentioned above, extended into the Middle Atlantic States on the 7th and caused the ice to break up in the Susquehanna River. Fortunately it passed out on stages somewhat below the flood level.

The rains of the 12th and 13th were unusually heavy over the watershed of the Schuylkill River in southeastern Pennsylvania and caused a very rapid rise in that stream on the 13th, the rise quickly subsiding.

Arizona.—Following the general heavy rains of the 28th to 30th, freshet conditions developed rapidly in the streams of the southern half of Arizona. In the Salt River and its tributaries considerably higher stages resulted than occurred in the freshets of December, 1914. By the morning of the 31st the crest of the rise had passed into the Gila River, below the mouth of the Salt.

Practically all of the floods were forecast, and in general but little preventable damage was sustained.

Statistics of flood loss during January, 1915.

State.	Tangible property.	Crops (gathered), and live stock.	Crops (prospective).	Suspension of business.	Saved by warnings, (estimated amount.)
South Carolina	$1,325	$1,605	$12,500	$9,696	$65,400
North Carolina				5,000	15,000
Alabama					3,300

SNOWFALL AT HIGH ALTITUDES, JANUARY, 1915.

[As summarized from the reports of Section Directors.]

Arizona.—Throughout January there was but little addition to the snow in the mountain districts until the last decade of the month. The excessive precipitation of the 28th and 29th occurred mostly in the form of snow over the northern plateaus and ranges, at the higher levels of the central mountain districts, and over the east-central ranges, as far south as the Blue Mountains. In the more southerly ranges of the southeast, even at extreme elevations in some sections, the storm set in with rain, melting all, or a considerable part of the snow then remaining, and ended with snowfall insufficient in depth in most localities to reach the average for the season in past years.

Observers in nearly all sections particularly mention, in connection with their reports upon snow conditions, the prospect for an abundant water supply for agricultural and grazing purposes during the spring and early summer.—*Robt. R. Briggs, Section Director.*

California.—The snowfall in California during January, 1915, was considerably below the normal in most portions of the Sierra Nevada Mountains, only slightly below in the Siskiyou, and somewhat above normal in the mountains of southern California. The snow-covered area of the State was large at the beginning of the month, and, while January was decidedly stormy with heavy precipitation, the snow fields were greatly reduced by the rains which extended well into the mountains and melted the snow generally below the 3,000-foot level.—*G. H. Willson, District Forecaster.*

Colorado.—In common with the three preceding months, the snowfall during January was less than normal on all watersheds, the slight excesses occurring here and there at moderate elevations failing to offset marked deficiencies near the Continental Divide. The relatively scanty snow covering has permitted deep freezing. It follows that when melting sets in the runoff will be direct and rapid, and that the midsummer flow will be small, unless showers in the mountains make up the deficit.

The depths at the end of January and on the corresponding date a year ago, respectively, were:

TABLE 1.—*Snow on ground over Colorado, January, 1914 and 1915.*

Watershed.	1915	1914
	Inches.	*Inches.*
South Platte	6	23
North Platte	10	23
Arkansas	11	21
Rio Grande	16	24
Grand	15	36
Gunnison	18	41
Yampa and White	14	33
San Juan and southwestern watersheds	23	35

—*F. H. Brandenburg, District Forecaster.*

Idaho.—The month of January opened with a marked deficiency in the supply of snow in the mountains of Idaho, except in the Panhandle. The precipitation of the month was almost everywhere below normal. Most of the precipitation occurring in the early days of the month was in the form of snow, and measurements made on the 15th showed a considerable increase in depth. During the last week of the month there were a few days of abnormally high temperature, with warm winds and some rain, even in the higher mountains. These conditions materially reduced the depth of snow, but increased its density. While the conditions at the close of the

month were better than at the beginning, they were still far from satisfactory, the prospect being for a deficient flow of water in all the streams.—*Edward L. Wells, Section Director.*

Montana.—January, 1915, was the third consecutive month with deficient snowfall in the mountain regions of the State. With but a few local exceptions there was a pronounced deficiency in precipitation at lower altitudes and the snowfall in the high mountain ranges appears to have been correspondingly light. Practically all reports from high elevations agree that the depth of snow is much less than normal and that it is not as solidly packed as is usual at this season of the year. The outlook at the end of the month for a normal flow of water during the summer of 1915, so far as the supply depends upon the winter accumulation of snow, is therefore not favorable.—*R. F. Young, Section Director.*

New Mexico.—The month was cold, wet, and stormy, especially over that part of the State west of the one hundred and fifth meridian. More than twice the normal snowfall occurred. The average for the State was 7.1 inches, making a total average fall for the winter thus far of 19.1 inches.—*Charles E. Linney, Section Director.*

Nevada.—The snowfall for January, 1915, was below normal in all basins. There was an average of 27.7 inches in the Truckee Basin; 22.0 inches in the Carson Basin; 6.3 inches in the Walker Basin; and 6.1 inches in the Humboldt Basin. The greatest amount reported in the Truckee Basin was 45.5 inches, at Cathedral Park; in the Carson Basin, 22 inches at Markleeville; in the Walker Basin, 14.5 inches at Bridgeport; and in the Humboldt Basin, 21 inches at Eureka.—*H. F. Alciatore, Section Director.*

Oregon.—The snowfall in January, 1915, was very light and this was the third consecutive month with unusually deficient snowfall in the mountains of Oregon. Compared with last year, there was much less snow on all ranges, except on the eastern slope of the Cascade Mountains and at a few stations in the Blue Mountains, where somewhat greater depths were reported and that was fairly well packed. Compared with the normal there was considerably less snowfall in all sections, some stations reporting the least snow on the ground at the end of the year that has been known in 18 to 25 years. Under existing conditions the outlook for irrigation water during the coming season is unfavorable.—*E. A. Beals, District Forecaster.*

South Dakota.—The average snowfall in the elevated region of South Dakota, that is, the greater portion of the Black Hills region of the State, was 21.5 inches, which is much more than the normal.—*M. E. Blystone, Meteorologist.*

Utah.—At the close of January the snow in the mountains of this State averaged much less than normal. Very nearly every correspondent reported amounts below the average, and that the prospective water supply, based on observations taken January 31, was below normal. Indeed, some report that the outlook was discouraging. The forest rangers report that the snow in all the forest reserves of this State was below normal, and, moreover, that the condition was favorable for early melting, while nearly all other observers reported that the snow was loose and that there were very few drifts.—*A. H. Thiessen, Section Director.*

Washington.—Observers from many different localities of the State agree that the January snowfall was unusually light in the mountains and highlands, and that up to the present the total winter's snowfall has been the least in 20 years or more. In the foothills of the Blue Mountains it is reported that wells and springs are dried up that were not dry before in 17 years. In the valleys of the northeastern section of the State there is nearly as much snow on the ground as on the higher elevations, owing to the uniformly cold weather during the month, preventing the melting that usually occurs at the lower levels.

At the end of the month there was little snow below the 2,000-foot level west of the Cascade summits. On the eastern slope the average monthly snowfall was about 30 inches of loose snow, a little more than half of what fell a year ago during the same period. The average depth at the end of the month was 21 inches, whereas in 1914 it was 34 inches. The density, as determined at Bumping Lake, was 21 per cent, which would give a water equivalent of 4.41 inches for the average depth of 21 inches.

In the Okanogan highlands the monthly snowfall averaged 10 inches in the valleys, whereas in 1914 it was 22 inches. In the Blue Mountains there was considerably less snow than in the corresponding period of 1914.—*G. N. Salisbury, Section Director.*

Wyoming.—While snow depths at elevations ranging from 6,000 to 10,500 feet averaged more than two and a half times as great as those at the close of the preceding month, yet nearly all observers report less than the normal amount for the season. The greater part of the snowfall occurred in the last half of the month, except in the Yellowstone Park, where it occurred in the first half. Owing to the absence of snow in the early part of the month the earth was frozen to an unusual extent and many mountain streams were frozen solid. As the temperature for the month averaged below normal, little snow disappeared by melting.

Estimates of density were made by observation, which showed an average water content. Measurements made at the end of the month at Centennial, near the base of the Medicine Bow Mountains, showed a density of 17 per cent. At high elevations the snow was reported as generally well packed by high winds and, consequently, of more than average density.

The average depths at the end of January and December, respectively, are given in Table 2.

TABLE 2.—*Snow on ground over Wyoming, January, 1915, and December, 1914.*

Station.	January.	December.
	Inches.	*Inches.*
Big Horn watershed	12	4
Cheyenne	16	3
Green	19	9
North Platte	18	8
Powder	7	2
Snake	18	6
Yellowstone	11	3
Tongue	10	2
Gallatin and Madison	21	8

—*R. Q. Grant, Section Director.*

MEAN LAKE LEVELS DURING JANUARY, 1915.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., Fe . 4, 19.5.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during January, 1915:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	601.81	579.44	571.09	244.70
Above or below—				
Mean stage of December, 1914	−0.27	−0.18	−0.29	−0.13
Mean stage of January, 1914	−0.60	−0.63	−0.96	−0.90
Average stage for January, last 10 years	−0.22	−0.63	−0.72	−0.97
Highest recorded January stage	−0.97	−3.23	−2.46	−2.90
Lowest recorded January stage	+0.93	+0.36	+0.13	+0.90
Probable change during February, 1915	−0.2	0.0	−0.1	+0.1

THE WATER RESOURCES OF STRAWBERRY CREEK, BERKELEY, CAL.

By WILLIAM G. REED and HOWARD M. LOY.

[Dated: University of California, Dec. 17, 1914.]

Of the problems of immediate practical importance to the State of California at least two—that of frost and that of available water supply—are from their nature largely meteorological. In both these problems the importance of intensive studies of small areas is being recognized more and more as time goes on.

Because of the necessities of the university a study of the water resources of Strawberry Creek, which flows through the campus, has interested the university administration and the College of Civil Engineering. The wide variety of conditions in the drainage area of the creek, together with its small extent, about 1 square mile, also make it an interesting locality for the study of local rainfall variations and raingage exposure. As the flow of the stream is measured by a recording weir, the relation of rainfall to run-off may also be studied from this area. In view of these facts the problem of the water resources of Strawberry Canyon was undertaken as a senior thesis by by Mr. Loy, of the College of Civil Engineering of the University of California. Prof. Charles Gilman Hyde had the general direction of the thesis work, and the senior author of this paper assisted in the meteorological aspects of the study. The work done during the year 1913–14 by Mr. Loy is the beginning of a study which it is hoped may be carried on for several years. During the present winter the study is being made by Mr. M. K. White with additional raingages and in the light of the work done in 1913–14.

Topography.—The general topographic features of the drainage area and the positions of the raingages in service may be seen from the map (fig. 1) of this portion of the Berkeley Hills. The character of the soil and the geological structure of the region are such that practically all the water which falls on the drainage area either flows over the wier (*W* in fig. 1) or is evaporated from the drainage area. Strawberry Creek is a torrential stream, its main channel having a grade of about 400 feet to the mile. The drainage area of the creek above the wier is about 600 acres. The portion of the area north of the creek is larger than that south of the creek and the slopes are less steep. The entire area is, however, cut by ravines, so that rain water finds its way into the creek almost immediately. Strawberry Canyon is surrounded by a ridge, or spurs of ridges, varying in altitude from 1,200 to 1,500 feet above sea level. The elevation of Strawberry Creek at the wier is about 500 feet.

Sources.—In the study of the rainfall and run-off, data from the following sources were available:

(1) Rainfall amounts for the 12-hour periods ending at 8 a. m. and 8 p. m., 120th meridian time, on the university campus, from readings of an 8-inch gage 15 feet above the ground, but sheltered from wind by trees at some distance.

(2) Automatic records from a Friez tipping-bucket raingage on the university campus, 60 feet above the ground and not sheltered from the sweep of the wind.

(3) Rainfall amounts from five 8-inch gages exposed on the ground in the drainage area as indicated in figure 1.

(4) Stream-flow records from the recording weir located in the main channel of Strawberry Creek (*W* in fig. 1).

The rainfall records from both gages on the campus are in essential accord in spite of the difference in exposure conditions. The gages exposed on the drainage area were located with the intention of getting exposures at different altitudes more or less uniformly distributed over the area. The locations of the gages are shown by the figures on the accompanying map (fig. 1). Table 1 shows the essential conditions of the exposure of each of the five gages exposed on the drainage area. The position of the gages was somewhat influenced by the necessities of observation; they were so located that it was possible to make the round of the gages after each storm when the ground was in poor condition.

TABLE 1.—*Conditions of exposure of field raingages in Strawberry Canyon.*

Gage No.[1]	Altitude A. M. S. L.	Angle of slope.		Height of rim above ground.	Exposure.
		Above gage.	Below gage.		
	Feet.	°	°	*Inches.*	
1	520	4	28	20	Near creek bed. Well surrounded by vegetation. Near steep south side of canyon.
2	730	18	14	20	Similar to gage No. 1.
3	880	30	22	15	Ridge between two branches of creek. More exposed to wind than gages Nos. 1 and 2.
4	1,225	24	20	15	Shallow depression at head of small tributary.
5	1,270	12	22	15	Bare ridge. Exposed to sweep of the wind.

[1] These numbers correspond to those on the map, fig. 1.

The discharge of the stream is measured by a triangular weir, a form recognized as more accurate for a stream which varies widely, than a rectangular weir. The opening of the weir is V-shaped, with an angle of 90° at the bottom, the sides of the V are angle iron, so that the opening is sharp. The discharge is computed by Thompson's well-known formula

$$Q = 2.64\, h^{\frac{5}{2}}$$

where Q is the discharge in second-feet and h is the head in feet.

The recording device indicates simply the level of the water flowing over the weir. It consists of a pencil attached to a float working in a well beside the weir and recording with a scale of 1:1 on a sheet of paper wrapped around a wooden cylinder which is turned by clockwork at the rate of about $\frac{1}{8}$ inch per hour, making a complete revolution in one week.

Results.—Perhaps the most important result of the study during the year was the recognition of the great difference in the catch of the gages. Probably this difference was due to exposure conditions. While it was, of course, recognized that the catch of the gage was dependent on the exposure, it was hoped that the results at the different gages might give an idea of the precipitation in the immediate vicinity of each gage. Table 2, which presents the records of the gages at the end of each storm,

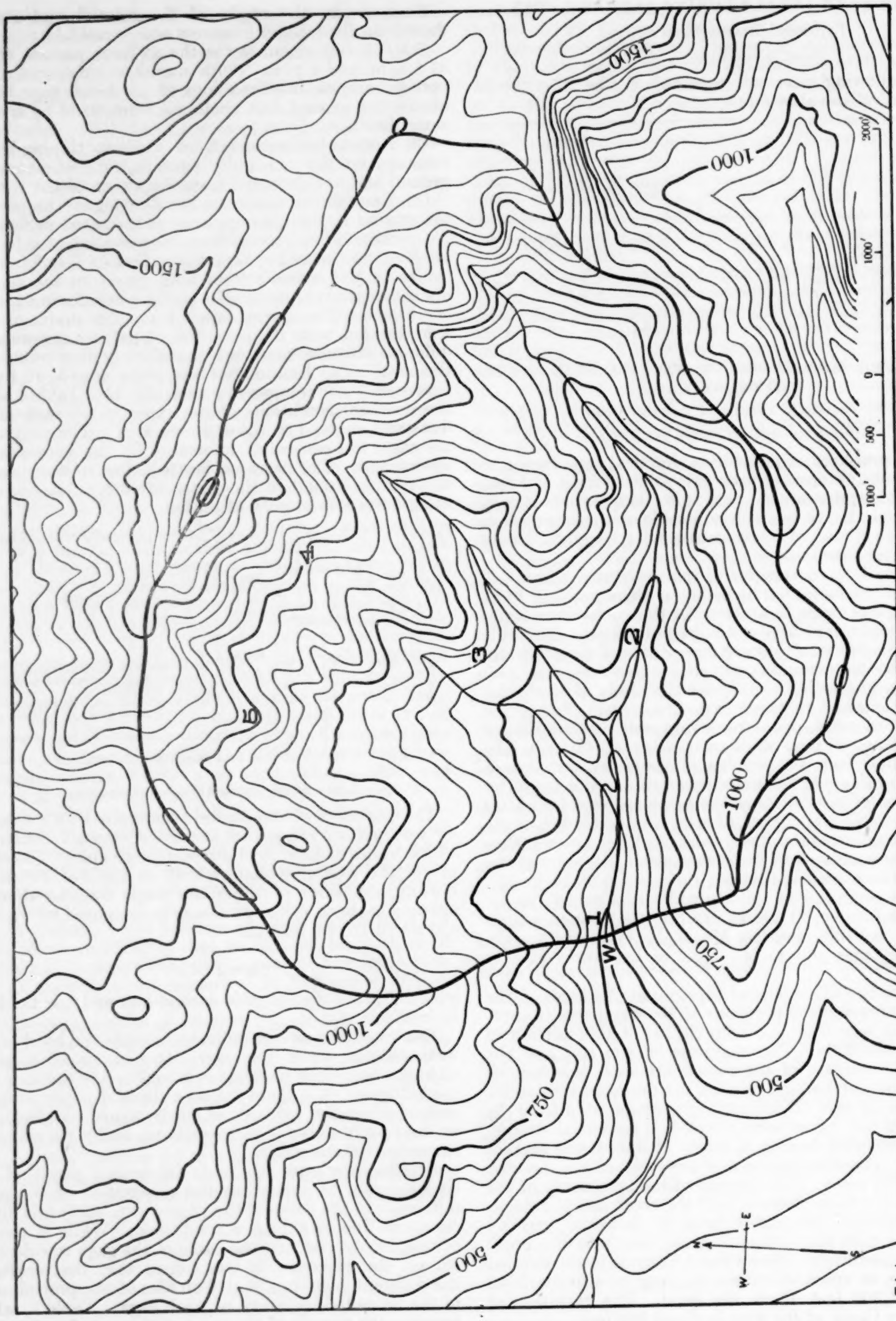

FIG. 1.—Contour map of Strawberry Creek, Berkeley, Cal., by W. H. Otis. Contour interval, 50 feet. Weir located at W; raingages located at points numbered 1, 2, 3, 4, and 5.

shows the great difference in the catch of the different gages. Contrary to the usual condition in California and elsewhere the gages at the higher levels showed a smaller amount of precipitation than those in the bottom of the canyon. It is not yet clear whether the reason for this is to be found in the sheltering trees and bushes which restrict the sweep of the wind, or in the more complicated question of the effective elevation of the raingages.

TABLE 2.—*Precipitation, in inches, at Berkeley, Cal., July 1, 1913, to June 30, 1914.*

1913.

Date.	Jl.	Ag.	Sp.	Oc.	November.							December.						
							Field gages.							Field gages.				
	Obs.	Obs.	Obs.	Obs.	Obs.	C. E.	1	2	3	4	5	Obs.	C. E.	1	2	3	4	5
1					0.94	0.95												
2					0.02	0.02												
3					0.02	0.02												
4					0.36	0.30												
5					0.01	0.02												
6					0.08	0.08												
7																		
8																		
9																		
10					0.13	0.11						0.21	(*)					
11					0.14	0.16						0.03	(*)					
12					0.35	0.43						0.35	(*)					
13					0.15	0.11						0.16	(*)	0.85	0.90	0.72	0.72	0.52
14																		
15																		
16																		
17																		
18					1.40	1.25												
19					0.01	0.01	1.51					0.19	(*)					
20					0.59	0.57	0.68	0.65						0.23	0.21	0.27	0.32	0.22
21												0.59	(*)					
22	0.09											1.00	(*)					
23	0.10											0.21	(*)					
24					0.21	0.21						0.55	(*)					
25					0.01	0.01	0.24	0.26				0.24	0.22					
26		T.												3.17	2.99	2.39	2.17	1.13
27		0.30			1.00	0.98	0.96	0.94										
28		T.																
29					0.46	0.59	0.50	0.48	0.47			0.57	(*)					
30												1.58	(*)					
31				0.36								1.30	(*)	4.00	4.35	3.37	3.06	1.68
Total	0.19	0.30	....	0.36	5.83	5.82						6.98	....	8.25	8.45	6.75	6.27	3.55

1914.

Date.	January.							February.						
			Field gages.							Field gages.				
	Obs.	C. E.	1	2	3	4	5	Obs.	C. E.	1	2	3	4	5
1	0.26	(*)												
2	1.02	(*)	1.48	1.61	1.24	1.12	0.62							
3														
4														
5														
6														
7	0.52	(*)												
8			0.60	0.62	0.56	0.56	0.51							
9														
10														
11														
12	2.28	(*)												
13	0.36	(*)												
14	1.46	(*)												
15														
16	T.	(*)	4.37	4.48	3.85	3.39	2.25	0.03	0.02					
17	1.59	(*)						0.08	0.07					
18	0.20	(*)						0.63	0.57					
19	0.18	(*)						0.48	0.49					
20	T.	(*)						1.79	1.74					
21	0.90	(*)						0.38	0.37					
22	1.16	(*)						0.58	0.58					
23	0.41	(*)								4.47	4.56	4.00	3.80	2.92
24	1.32	(*)	6.90	6.98	5.87	5.95	3.10							
25	0.86	(*)						0.01						
26	0.19	(*)												
27	0.03	(*)	1.06	1.14	0.66	0.66	0.41							
28														
29														
30														
31														
Total	12.74	...	14.15	14.83	12.18	11.68	6.89	3.98	3.84	4.47	4.56	4.00	3.80	2.92

TABLE 2.—*Precipitation, in inches, at Berkeley, Cal., July 1, 1913, to June 30, 1914*—Continued.

1914—Continued.

Date.	March.							April.							My.	Je.
			Field gages.							Field gages.						
	Obs.	C. E.	1	2	3	4	5	Obs.	C. E.	1	2	3	4	5	Obs.	Obs.
1	0.02							0.01								
2		0.02	0.02	0.02	0.02	0.02	0.02									
3															T.	
4								0.58	0.52	0.62	0.67	0.61	0.55	0.36		
5																
6																0.33
7																0.05
8								0.07	0.07						0.21	
9								0.31	0.30							
10								0.19	(*)	0.61	0.65	0.59	0.54	0.35		
11																
12																
13																
14															T.	
15															0.05	
16																
17																
18																
19																0.09
20																
21								0.06	(*)							
22								0.07	(*)						0.08	
23										0.22	0.22	0.19	0.22	0.25	0.13	
24															0.14	0.01
25															0.01	
26																
27								0.05	0.04							
28	T.									0.06	0.08	0.07	0.08	0.07		
29	T.															
30	0.94	0.96														
31	0.03	0.04	0.98	0.96	0.86	0.85	0.82									
Total	0.99	1.02	1.00	0.98	0.88	0.87	0.84	1.33	....	1.51	1.62	1.66	1.39	1.03	0.62	0.48

* Recording gage out of order.
Obs.=gage at Students Observatory, read twice daily, 8 a. m. and 8 p. m. P. S. T.
C. E.=Recording gage on roof of Civil Engineering Building.
1=field gage placed Nov. 17; read after each storm.
2=field gage placed Nov. 19; read after each storm.
3=field gage placed Nov. 28; read after each storm.
4=field gage placed Dec. 1; read after each storm.
5=field gage placed Dec. 1; read after each storm.

The winds during precipitation are almost always from the south and the southeast and, therefore, cross the ridge to the south of the canyon. It may well be that the effective height of the gages at the foot of the steep south ridge is the same as that of the ridge; in other words the elevation from which precipitation occurs is that of the crest of the ridge rather than that at which the gages are located. An effort is being made during 1914–15 to obtain rainfall measurements from the crest of this ridge itself to determine, if possible, what the relation is. It will be noted from Table 2 that the precipitation at gage 2 is larger than that at gage 1 and from the map that the portion of the ridge to the south of gage 2 is higher than the portion to the south of gage 1.

The relations between the run-off as measured by the weir and the rainfall as shown by the record from the gage at the Students' Observatory is shown by Table 3. A study of the fragmentary records before 1910 together with the records from the recording wier shows that in seasons with about the average precipitation of 26 inches, the run-off is from 0.25 to 0.31 of the rainfall. For seasons of lighter rainfall the percentage is greatly decreased, thus in 1911–12 and in 1912–13, it is 0.048 and 0.041, respectively. The relation between precipitation and the flow of Strawberry Creek is shown by figure 2, which shows the daily rainfall at Berkeley and the run-off as measured by the recording weir.

The studies made during 1913–14 form the beginning of a series which will increase in usefulness as it becomes more complete. It is hoped that the University of California will be able to continue this intensive study of rainfall and run-off in Strawberry Canyon until the amount of water available and the relation between the precipitation and the stream flow in the east bay region may be determined with accuracy.

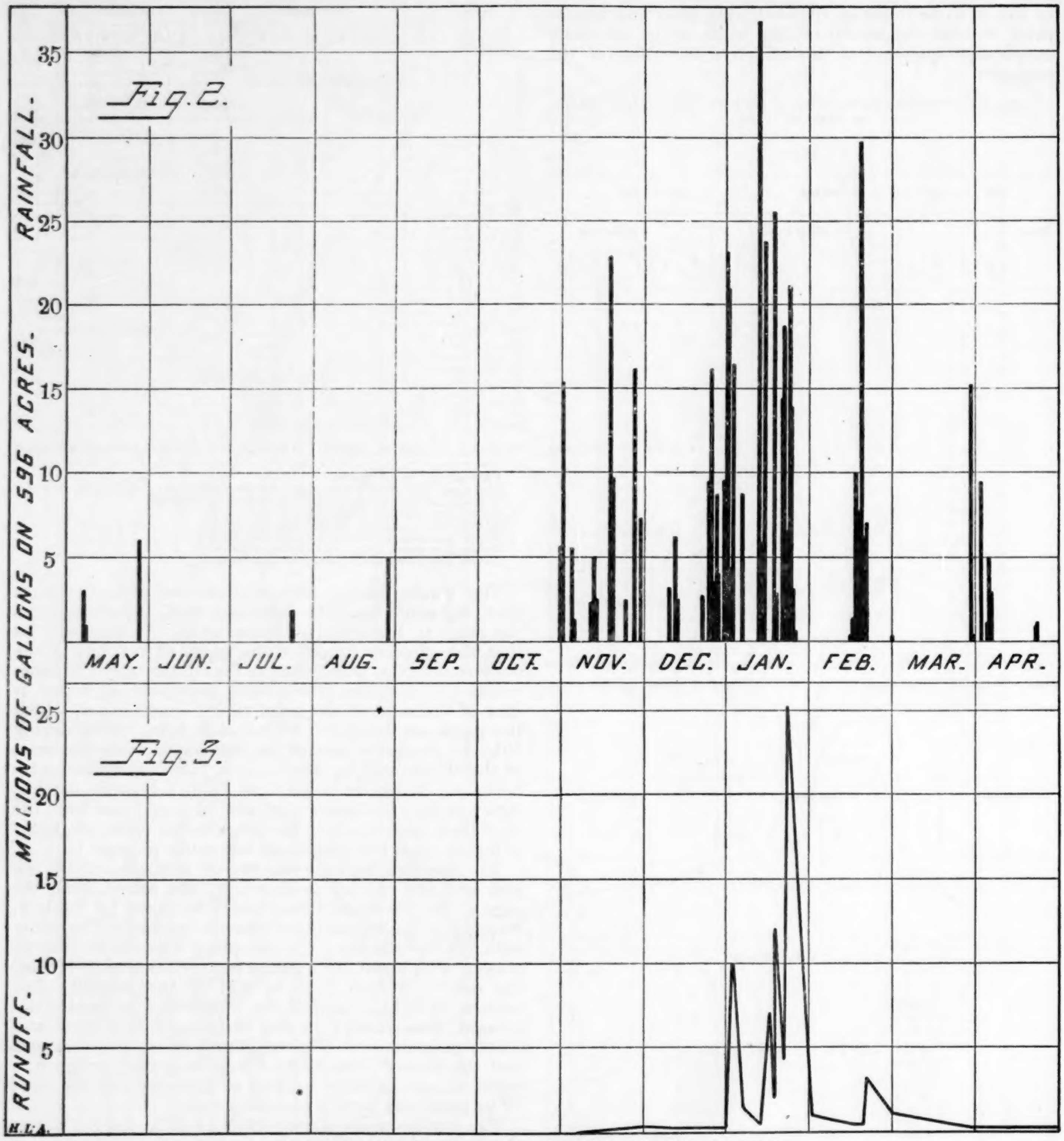

FIG. 2.—Daily rainfalls in gallons over Strawberry Creek basin, Berkeley, Cal., 1913-14.

FIG. 3.—Daily discharges in gallons of Strawberry Creek, Berkeley, Cal., 1913-14, measured by the recording weir.

TABLE 3.—*Rainfall and run-off in Strawberry Canyon.*

[Millions of gallons.]

Month.	1910-11			1911-12		
	Rainfall.	Run-off.	Ro/Rf.	Rainfall.	Run-off.	Ro/Rf.
July	0.00	0.355	....	T.	1.221	....
August	0.00	0.279	....	0.00	0.842	....
September	0.971	0.149	0.154	T.	0.430	....
October	9.710	0.256	0.026	11.820	0.712	0.060
November	14.100	0.520	0.037	7.445	0.354	0.048
December	29.150	0.658	0.023	40.650	0.788	0.019
January	258.800	33.636	0.130	59.100	1.892	0.032
February	65.600	47.740	0.728	8.750	0.850	0.097
March	83.700	52.928	0.534	47.900	2.091	0.044
April	25.250	11.991	0.475	23.800	0.784	0.033
May	4.370	4.001	0.916	25.250	0.800	0.032
June	0.648	2.041	3.145	13.780	0.644	0.047
Season	492.299	154.564	0.314	238.495	11.407	0.048

TABLE 3.—*Rainfall and run-off in Strawberry Canyon*—Continued.

[Millions of gallons.]

Month.	1912-13			1913-14		
	Rainfall.	Run-off.	Ro/Rf.	Rainfall.	Run-off.	Ro/Rf.
July	0.324	0.200	0.617	3.000	0.000	....
August	0.000	0.130	....	4.800	0.000	....
September	23.630	0.150	0.006	0.000	0.000	0.000
October	11.340	0.177	0.016	5.830	0.000	....
November	62.800	0.132	0.002	94.400	0.207	0.002
December	26.210	1.085	0.042	107.859	15.307	0.142
January	61.200	5.617	0.092	193.800	162.178	0.838
February	10.370	1.055	0.102	64.000	21.851	0.342
March	32.050	1.053	0.033	14.900	11.276	0.753
April	9.230	0.602	0.065	23.340	4.489	0.193
May	16.030	0.169	0.011	....	....	....
June	T.	0.060	....	....	....	....
Season	253.264	10.430	0.041	....	....	....

SECTION V.—SEISMOLOGY.

REPORTS FOR JANUARY, 1915.

By W. J. HUMPHREYS, Professor of Meteorological Physics, in charge of Seismological Work.

[Dated Weather Bureau, Mar. 1, 1915.]

The following extract from the instructions issued by the Weather Bureau, for the noninstrumental observation of earthquakes may interest those unacquainted with this portion of the bureau's seismological work.

Request for cooperative observers.

Although each of the Weather Bureau's regular stations, approximately 200, will report all earthquakes felt, yet the territory covered is so great that its seismic disturbances can not adequately be recorded without the aid of a large number of voluntary assistants. Hence it is earnestly hoped that, so far is possible, all the bureau's numerous cooperative observers will assist also in the collection of seismological data, by reporting, on cards that will be furnished for that purpose, the date, etc., of each earthquake that they may experience. To each observer the labor will be exceedingly light, and the time consumed only a few minutes in a whole year, but the collected results will be permanent and extremely valuable—absolutely essential to the construction of the maps in question [viz, maps that locate geologic faults and indicate their activity in the production of earthquakes] and exceedingly helpful in the explanation of many obscure earthquake phenomena.

Instructions for the collection of earthquake data.

The particular earthquake data desired is indicated on the question cards that will be supplied to all who take part in this work, but the method of collecting and forwarding this information to the Central Office for classification and study is explained by the following instructions:

1. Regular Weather Bureau stations will be communicated with directly from the Central Office; cooperative stations entirely by, or, when necessary, through section centers.
2. All routine communications on seismology directed to the Central Office will be inclosed in penalty envelopes marked "Seismology."
3. Each regular Weather Bureau station and each cooperative station that agrees to assist in this work will be furnished with a supply of question cards [as published last month].
4. Each station, regular and assisting cooperative, will promptly fill out and forward in a penalty envelope one question card for each earthquake felt.
5. The regular stations at Boston, Atlanta, St. Louis, Denver, and San Francisco will also send to the Central Office such newspaper clippings in regard to earthquakes in the United States as may come to their notice.
6. Each section center may supply question cards to other reliable persons in addition to the cooperative observers. This is especially desirable in those portions of the country which are either subject to earthquake shocks or sparsely inhabited.
7. An earthquake that produces any appreciable damage will be made the subject of a special investigation determined upon at the time.
8. All question cards collected by section centers recording the occurrence of an earthquake will be promptly forwarded to the Central Office.

TABLE 1.—*Noninstrumental earthquake reports, January, 1915.*

Day.	Approximate time Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
	h. m.	CALIFORNIA.	° ′	° ′			m. s.			
12	4 33	Bakersfield	35 22	119 0	5	2	5			Santa Fe Co.
	4 33	Lonoak	36 20	120 0	2	2	2			Martin L. Griffin.
	4 33	Nordhoff	34 35	119 14	3	1		Faint		W. H. Duncan.
	4 33	Ozena	34 53	119 16	5	1	6	Faint		J. D. Reyes.
	4 33	Paso Robles	35 34	120 40	4	2	5			Dr. F. W. Sawyer.
	4 33	San Luis Obispo	35 18	120 39	5	4	30			U. S. Weather Bureau.
	4 33	Santa Barbara	34 23	119 40	5	1	5	Faint	Lamps swung	G. W. Russell.
	4 33	do	34 23	119 40	6	1	5			Forest Service.
12	14 15	Aguanga	33 26	116 51	4	2	4	Rumbling		Forest Service.
	14 15	Mesa Grande	33 11	116 42	2	1	2	Rumbling		E. H. Davis.
14	15 30	Rohnerville	40 33	124 11	4	1	2			W. D. Gray.
	15 30	Shively	40 25	123 56	3	2	2	Faint		Frank Essig.
17	4 53	Coyote	37 14	121 44	3	1	1			Stanley Sharp.
20	19 30	Brawley	32 50	115 40	3	2	1			M. D. Witter.
26	10 30	do	32 50	115 40						M. D. Witter.
28	15 00	do	32 59	115 40	2	1		Rumbling		M. D. Witter.
31	8 30	Branscomb	39 40	123 40	3	4	4			A. J. Haun.
		OREGON.								
19		Summerville	45 27	118 05	5					Press at La Grande, Oreg.
		TENNESSEE.								
14	9 20	Bristol	36 36	82 12	3-4	1	20		Rattled windows	B. F. Sperow.
		WASHINGTON.								
26	0 55	Longmire	46 48	121 56	4	1	½	Loud		Forest Service.

TABLE 2.—*Instrumental reports, January, 1915.*

[Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.]

[For significance of symbols see REVIEW for December, 1914, p. 689.]

District of Columbia. Washington. U. S. Weather Bureau.

Lat., 38° 54′ N.; long., 77° 03′ W. Elevation, 21 meters.

Instrument: Marvin (vertical pendulum).

Date.	Character.	Phase.	Time.	Period T.	Amplitude A_E	Amplitude A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Jan. 5-6	II_r	eP_N	23 45 17	4			3,960	Phases not distinct.
		S_N	23 51 32	7				
		L_N	23 55 25	16				
		M_N	23 56 37			16		
		F	0 53 00					
13	II_u	P?	(?)					P, L_N, and F lost in strong microseisms. Destructive earthquake in Italy.
		S_N	7 11 35	10				
		L_N	(?)					
		L	7 28 00		16	14		
		F	8 (?) 00					

District of Columbia. Washington. Georgetown University. F. L. Tondorf, S. J.

Lat., 38° 54′ 25″ N.; long., 77° 04′ 24″ W. Elevation, 42 meters. Subsoil: decayed diorite.

Instruments: Astatic pendulums after Wiechert, 200 kgm. (horizontal).

Instrumental constants	V	T_0	ϵ
A_N	143	5.2	3.4
A_E	165	5.4	2.6
A_Z			

Date.	Character.	Phase.	Time.	Period T.	Amplitude A_E	Amplitude A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Jan. 5	III_r	iP_N	23 52 45.4				1,800?	E-W not discernible. Vertical instrument in repair.
		S_N	23 57 18					
		L_N	23 57 40.6	10	161*			
13	I_r	L_N	7 28 40	15	500*	290*	?	Phases not discernible, lost in microseisms. Reported in Rome.
		L_E	7 23 20	15				
		F_N	7 36 40	?				
		F_E	7 33 00	?				

* Trace amplitudes.

Massachusetts. Cambridge. Harvard University. J. B. Woodworth.

Lat., 42° 22′ 36″ N.; long., 71° 06′ 59″ W. Elevation, 5 meters.

Instruments: Two Bosch-Omori.

Date.	Character.	Phase.	Time.	Period T.	Amplitude A_E	Amplitude A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Jan. 5-6		*O*	23 37 39				3,950	N. B.—Pendulums undamped. *O* equals time at origin calculated from Brit.
		eP_N	23 44 56					
		S_E	23 50 40					
		eL	23 54 01	10-15				
		M_E	0 18 22	24				
		L_N	0 32 36	20				
		F	0 56 00					
10		*O*?	Indeterm.					e in microseism Time interpolated because of failure of minute ticks.
		eL?	23 24 26	20-15				
		F	23 45 00					
13		*O*	6 52 29				6,750	All phases superposed on microseisms. P to S on N component illegible. Maximum ill-defined. Destructive earthquake reported about Lago di Fucino in central Italy. Origin near 42° N., 13° E.
		eP_E	7 02 45					
			7 04 17	4				
		S_E	7 11 01	15				
		eL_E	7 19 21	35				
			7 22 24	25				
			7 26 25	20				
		M_E	7 27 48	20	(1.1 mm.)			
		F	8 05 00					
27		*O*						Between 1h and 2h. No decided maximum.
		eN?	1 37 44					
		L_E	1 40 30	40				
			1 41 14	22				
			1 43 37	16				
			1 45 42	20				
			1 48 18					
		L_E	1 49 04	20-16				
		L_N	1 51 33					
		F_E	2 12 00					

Missouri. St. Louis. Geophysical Observatory, St. Louis University. J. B. Goesse, S. J.

Lat., 38° 38′ 15″ N.; long., 90° 15′ 58″ W. Elevation, 160 meters. Foundation: 12 feet of tough clay over limestone of Mississippi System, about 300 ft. thick.

Instrument: Weichert 80 kgm., astatic, horizontal pendulum.

Instrumental constants: $\begin{cases} V & T_0 & \epsilon:1 \\ 80 & 7 & 5:1 \end{cases}$

Date.	Character.	Phase.	Time.	Period T.	Amplitude A_E	Amplitude A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Jan. 13	I_r	eS_E	7 11 15				6,600	No P on either component. Reported from Italy. This disturbance was preceded and followed by almost continuous microseisms, which at times were of unusual character; the records show such on Jan. 12, 13, 14, and 15. Jan. 29 and 30 the records show frequent microseisms of the usual kind.
		L	7 20 02					
		L	7 28 to 7 42 05					
		M_E	7 36 40	22				
		F	7 45 00					

Vermont. Northfield. U. S. Weather Bureau.

Lat., 44° 10′ N.; long., 72° 41′ W. Elevation, 256 meters.

Instruments: Two Bosch-Omori.

Date.	Character.	Phase.	Time.	Period T.	Amplitude A_E	Amplitude A_N	Distance.	Remarks.
1914.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Dec. 20	I_u	P_E	14 27 36				8,875	All phases uncertain.
		PR_E	14 34 35					
		PR_N	14 35 32					
		S_N	14 37 40					
		L_N	14 54 35					
		F	15 50 00					
25	I_r	P_N?	3 47 45				2,690	All phases uncertain.
		S_N	3 52 05					
		L_N	3 54 35					
		M_E	3 57 00					
		M_N	3 59 00					
		F	4 10 00					
1915. Jan. 5-6		M_N	23 54 56					P, S, and L lost in process of changing sheet.
		F	1 00 00					
13	II_u	P_E	7 02 52				6,945	Phases indistinct, strong microseisms prevailed. Earthquake in Italy.
		S_N	7 11 18					
		L_N	7 19 15					
		F	8 00 00					
27		L_N	1 57 00					Faint.

Canada. Ottawa. Dominion Astronomical Observatory. Otto Klotz.

Lat., 45° 23′ N.; long., 75° 43′ W. Elevation, 83 meters.

Instruments: Two Bosch photographic pendulums.

Date.	Character.	Phase.	Time.	Period T.	Amplitude A_E	Amplitude A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Jan. 5-6		P	23 45 07				4,220	
		S	23 51 07					
		L_N	23 54 04	20				
		L_E	23 54 05	20				
		L	24 01 00					
		L	24 06 00 – 24 28 00	18				
		F	24 45 00					
13		P	7 02 57	2			6,860	Destructive earthquake in Italy. No marked maximum. Strong microseisms prevailed.
		S	7 11 19					
		SR_1	7 18 08	12				
		L	7 20 05	32				
		L	7 24 00	20				
		L	7 29 00 – 7 42 00	16-14				
		F	8 00 00					

TABLE 2.—*Instrumental reports, January, 1915*—Continued.

Canada. Toronto. Meteorological Service.

Lat ,43° 40′ 01″ N.; long.,79° 23′ 54″ W. Elevation,113.7 meters. Subsoil: sand and clay

Instrument: Milne horizontal pendulum, North. In the meridian.

T_0, 18. Pillar deviation, 1 mm. swing of boom=0″.59.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 4		L	10 07 42					Gradual thickening.
		M	10 10 12			200		
		F?	10 24 00					
5		P	14 59 36					M not defined.
		Pi	15 02 48					
		S	15 09 00					
		L	15 16 54					
		L	15 35 12					
		L	15 41 30					
		M	15 44 24			300		
		Li	15 46 36					
		F?	16 17 24					
5		P	16 45 00					Doubtful as being seismic.
		L	16 51 42			200		
		F	17 04 24					
5		L	17 28 42			100		Uniform thickening.
		F	17 32 06					
5		P	23 45 48					Marked disturbance.
		L	23 55 06					
		Li	23 56 00					
6		M	0 12 42			700		
		L	0 21 30					
		F	1 27 36					
7		P	12 37 00			500		
		F	12 54 48					
11		P	0 02 30					P doubtful.
		P	0 07 06					
		S	0 11 18					
		Li	0 24 12					
		M	0 28 03			800		
		F	0 51 24					
12		P	4 39 54			50		
		F	4 42 54					
13		P	7 12 12					Disastrous Italian quake. Registered at Rome, 6h 52m 55s, G. M. T.
		S	7 19 54					
		S	7 21 54					
		L	7 25 06					
		Li	7 30 42					
		M_1	7 32 24			2,800		
		M_2	7 34 12			2,600		
		C_1	7 38 12			1,300		
		C_2	7 38 48					
		L	7 46 12					
		F	8 34 00					
14		P	14 16 12					Doubtful as to being seismic.
		L	14 36 42			100		
		F	14 39 24					
17		P	7 57 06					Marked thickening. Doubtful as to being seismic.
		L	8 02 48			100		
		F	8 06 54					
22		L	5 45 18			50		
		F	5 48 00					
22		P	6 03 00			50		
		F	6 04 00					
26		P?	1 24 54					
		S?	1 30 36					
		L	1 49 36			100		
		L	1 54 30					
		F	2 27 00					
30		L	8 47 00			200		
		F	8 53 12					

Canada. Victoria, B. C. Meteorological Service.

Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: rock.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constants: T_0, 18. Pillar deviation, 1 mm. swing of boom=0″.54.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*h. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 4		P	1 15 42					
		L	1 19 42					
		M	1 24 42			200		
		F	1 37 42					
5		P	14 56 06					
		S	15 01 36					
		L	15 19 36					
		M	15 23 36			500		
		F	15 52 36					
5		P	23 39 24					
		S	23 43 24					
		L	23 49 24					
		M	23 51 06			1,000		
6		F	0 48 36					
7		P	12 35 30					
		L	?					
		M	12 42 30			100		
		F	12 49 30					
11		P	0 01 12					
		L	0 09 12					
		M	0 11 12			200		
		F	0 23 12					
12		P	4 35 00					
		L	4 40 30					
		M	4 41 00			100		
		F	4 47 00					
13		P	7 15 48					Disastrous Italian earthquake.
		S	7 21 48					
		S	7 26 24					
		L	7 31 36					
		Li	7 36 48					
		L	7 39 30					
		M	7 42 30			1,900		
		M	7 45 24			2,000		
		M	7 48 36			1,750		
		L	7 50 36					
		F	8 57 48					
22		P	5 56 06					
		M	5 57 06			200		
		F	6 01 06					
27		L	1 43 36?					
		L	1 57 36					
		M	2 03 06			200		
		F	2 17 36					
30		P	8 24 48					
		L	8 29 48					
		M	8 32 48			200		
		F	8 40 18					

SECTION VI.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Austria-Hungary. K. u. K. Hydrographisches Amt in Pola.
Jahrbuch der meteorologischen, erdmagnetischen und seismischen Beobachtungen. Neue Folge. 18. Band. Beobachtungen des Jahres 1913. Pola. 1914. xxiii, 150 p. 33½ cm.

Batavia. Royal magnetical and meteorological observatory.
Observations. Vol. 34, 1911. Containing meteorological and magnetical observations made in 1911. Batavia. 1914. xxviii, 95 p. [3] charts. 36 cm.

Burke, Edmund, & Pinckney, Reuben M.
A report on Montana climate. [With an appendix: Temperature records, 1898–1913.] Bozeman, Mont. 1914. 143 p. plate. 21½ cm. (Montana agricultural experiment station. Bulletin no. 99.)

Canada. Meteorological service.
Report, for the year ended December 31, 1911. Ottawa. 1914. 2 v. 29½ cm.

Chile. Instituto central meteorológico y geofisico.
Anuario meteorológico de Chile. Segunda parte (resúmenes). [Spanish and German text.] Santiago de Chile. 1914. viii, 125 p. [6] pl. 37½ cm. (Pub. no. 10.)
Medidas de agua caída en 1912. [Spanish and German text.] Santiago de Chile. 1914. iv, 61 p. 4 pl. 37½ cm. (Pub. no. 8.) [Anexo: Miguel Wittaker, Recopilación de sumas anuales de agua caída en Chile; Walter Knoche, Sumas compensadas del agua caída anual de La Serena, Valparaíso, Santiago (y Valdivia).]
Ondas hertzianas registradas en San Carlos de Ancud 1913, con una discusión preliminar por Walter Knoche. [Spanish and German text.] Santiago de Chile. 1914. 27 p. 37½ cm. (Pub. no. 9.)
Valores horarios de los elementos meteorológicos en Punta Arenas 1911 y 1912. [Spanish and German text.] Santiago de Chile. 1914. 67 p. [7] pl. 37½ cm. (Pub. no. 12.)
Valores horarios de los elementos meteorológicos en Santiago 1912. [Spanish and German text.] Santiago de Chile. 1914. 68 p. plates. 37½ cm. (Pub. no. 7.)
Valores horarios de los elementos meteorológicos y temperaturas del suelo en Santiago 1913. [Spanish and German text.] Santiago de Chile. 1914. 73 p. plates. 37½ cm. (Pub. no. 11.)

Great Britain. Meteorological office.
The observer's handbook, 1914. London. 1914. xxvii, 7–165 p. plates. 24½ cm.

Haute-Garonne. Commission météorologique.
Bulletin. Tome 3, premier fascicule, 1911. Toulouse. 1913. v. p. 6 charts. 28 cm.

Hinselmann, Emil J. N. Brandt.
Mond und Wetter im Jahre 1915. Hannover. 1915. 7, [12] p. 19 cm.

India. Meteorological department.
Memorandum on recent weather and on the probable character of that of January and February, 1915. Delhi. 1915. 3 p. 33½ cm.
Statement of actual rainfall in June, July, August and September, 1914, and a comparison of the forecasts with the actual rainfall. [Simla. 1915.] 8 p. 32½ cm.

Jameson, P. R.
The barometer as the foot rule of the air. Rochester, N. Y. [©1915.] 23 p. 20½ cm. (Published by Taylor instrument companies.)
Practical hints for amateur forecasters. [2d ed.] Rochester, N.Y. [©1915.] 21 p. 20½ cm. (Published by Taylor instrument companies.)

Japan. Central meteorological observatory.
Annual report for the year 1913: Meteorological observations. Tôkyô. 1914. 413 p. map. 30 cm.

Madrid. Observatorio.
Anuario para 1915. Madrid. 1914. 703 p. 18½ cm.

Marini, L[udovico].
Carte di pressione e di venti per il bacino Mediterraneo. Genova. 1914. 50 p. maps. 31 cm. (Estratto dagli Annali idrografici, vol. 9, anno 1913–1914.) [Includes tables and charts giving seasonal and annual normal pressures and prevailing winds, also seasonal and annual windroses, over the Mediterranean basin.]
Il cifrario internazionale per i telegrammi meteorici. Torino. 1914. 9 p. 2 pl. 27½ cm. (Estratto dal Bolletino bimensuale della Società meteorologica italiana.)

Norlind, Arnold.
Einige Bemerkungen über das Klima der historischen Zeit, nebst einem Verzeichnis mittelalterlicher Witterungserscheinungen. Lund & Leipzig. [1914.] 53 p. 25 cm. (Lunds universitets arsskrift, n. f., afd.1, Bd. 10, nr.1.)

Norway. Meteorologiske institut.
Aarsberetning, 1. Juli 1913 til 30. Juni 1914. Kristiania. 1914. 17 p. 22½ cm.

Prussia. K. Geodätisches Institut.
Seismometrische Beobachtungen in Potsdam, 1913. Berlin. 1914. 33 p. 28 cm. (Veröffentlichung, N. F., No. 62.)

Smith, J. Warren.
Lightning and lightning conductors. (*In* Proceedings and papers of the 19th annual meeting of the National association of mutual insurance companies, held at Columbus, Ohio, September 22–24, 1914. p. 23–42.)

Switzerland. Abteilung für Landeshydrographie.
Tabellarische Zusammenstellung der Hauptergebnisse der Schweizerischen hydrometrischen Beobachtungen für das Jahr 1912. [German and French text.] Bern. 1914. 83 p. 38 cm.

Witting, Rolf.
Jahrbuch 1913 enthaltend hydrographische Beobachtungen in den Finland umgebenden Meeren. Helsingfors. 1914. 134 p. 5 pl. 33 cm. (Soc. scien. Fennica. Finländische hydrographisch.-biologische Untersuchungen. No. 13.)

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Professor in charge of Library.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

American geographical society. Bulletin. New York. v. 47. February, 1915.
Packard, Leonard O. Response to rainfall in India. p. 81–99.

American journal of science. New Haven. v. 39. February, 1915.
Very, Frank W. On the solar constant. p. 201–208.

American society of civil engineers. Proceedings. New York. v. 41 February, 1915.
Binckley, George S., & Lee, Charles H. Suggested changes and extension of the United States weather bureau service in California. p. 251–258.

Carnegie institution of Washington. Year-book. Washington. 1914.
Shreve, Forrest. Progress in the measurement of the physical factors of an isolated desert mountain. p. 67.
Shreve, Forrest. The annual march of the ratio of evaporation to soil moisture. p. 68
MacDougal, D. T. Auxo-thermal integration of climatic complexes. p. 70–71.
Shreve, Forrest. The direct effect of rainfall on tropical hygrophilous vegetation. p. 83.
Livingston, B. E., & Shive, J. W. The non-absorbing atmometer. p. 83–84.

Carnegie institution of Washington. Year-book—Continued.
Livingston, B. E. Spherical porous cups for atmometry. p. 84–85.
Livingston, B. E., & Sampson, H. C. Atmometric units. p. 85.
Hayford, John F. Investigation of the laws of evaporation and stream flow. p. 376–377.
Engineering news. New York. v. 73. 1915.
Fleming, R. Wind pressure formulas and their experimental basis. p. 160–163. (Jan., 28.)
Fleming, R. Wind stresses in steel mill buildings. p. 210–214. (Feb., 4.)
Indian meteorological department. Memoirs. Calcutta. v. 22. pt. 3. 1914.
Walker, Gilbert T. Monthly and annual normals of pressure, temperature, relative humidity, vapour tension and cloud. p. 411–503.
Journal of geography. Madison. v. 13. February, 1915.
Ward, Robert DeC[ourcy]. The European winter and the war. p. 169–171.
Meteorological society of Japan. Journal. Tokyo. 34th year. January, 1915.
Okada, T. The remarkable glazed frost of Mukden of November 2 to 3, 1914. p. 1–4.
Nature. London. v. 94. January 21, 1915.
Aitken, John. The influence of icebergs on the temperature of the sea. p. 561–562.
Davis, G. M. Curious forms of ice. p. 563.
Davison, C. The earthquake in central Italy. p. 565.
Popular science monthly. New York. v. 86. February, 1915.
Palmer, Andrew H. Popular misconceptions concerning the weather. p. 128–141.
Royal meteorological society. Quarterly journal. London. v. 41. January, 1915.
Mill, Hugh Robert. Isomeric rainfall maps of the British Isles. p. 1–44. [Includes discussion.]
Stacey, W. F. Distribution of relative humidity in England and Wales. p. 45–64. [With discussion. Includes monthly and annual charts.]
Horton, Percy H. Mirage on the Cornish coast. p. 71.
Shaw, W[illiam] N[apier]. Meteorological observations at Holywell, Flintshire, 1793 to 1835. p. 71–73.
Marriott, W[illia]m. Meteorological observations at Addington, 1792–1793.
Shaw, W[illiam] N[apier]. Publication of values of rainfall in millimetres. p. 75–76.
Royal society. Philosophical transactions. London. ser. A. v. 214. A 520. 1914.
King, Louis Vessot. On the convection of heat from small cylinders in a stream of fluid: Determination of the convection constants of small platinum wires with applications to hot-wire anemometry. p. 375–432.
Science. New York. v. 41. February 12, 1915.
Arctowski, Henryk. A study of the influence of volcanic dust veils on climatic variations. p. 252–255.
Scientific American supplement. New York. v. 79. February 6, 1915.
Moreux, Th[éophile]. Protection from earthquakes. Principles of location and methods of construction found desirable. p. 90–91.
Symons's meteorological magazine. London. v. 49. January, 1915.
Bonacina, L. C. W. What do we mean by the seasons? p. 207–208.
Sedgwick, Walter. Weather in the seventeenth century. p. 209–213.
Académie des sciences. Comptes rendus. Paris. tome 160. 11 janvier 1915.
Cabannes, J. Sur la diffusion de la lumière par l'air. p. 62–63.
Boutaric, A. Sur la polarisation et le pouvoir absorbant de l'atmosphère. p. 75–80.
Annalen der Hydrographie und maritimen Meteorologie. Berlin. 43. Jahrgang. Heft 1. 1915.
Reinicke, G. Das Barozyklonometer. p. 19–23.
Thraen, A[ugust]. Ist die deutsche Seeküste ein einheitliches Niederschlagsgebiet? p. 24–31.
Himmel und Erde. Berlin. Jahrgang 26. Dezember 1914.
Hoerner, G. Donner und Blitz im altbayerischen Volksglauben. p. 565–567.
Meteorologische Zeitschrift. Braunschweig. Band 31. Dezember 1914.
Hann, J[ulius] v. Zum Klima von Abessinien, Addis Abeba. p. 561–566.
Sresnewsky, A. Eine Lösung des Problems der Korrelation zwischen zwei Veränderlichen, und über die Methode der gleichen Häufigkeiten. p. 566–572.
Meteorologische Zeitschrift. Braunschweig—Continued.
Staikoff, St. D. Die Fehlerrechnung in der Klimatologie. p. 573–579.
Schmidt, Ad. Friedrich Bidlingmaier. p. 579–580. [Obituary.]
Giacomelli, R. Eine neue Probe für die Richtigkeit der Differenzenmethode in der Ableitung von Mittelwerten aus Pilotvisierungen ungleicher Höhe. p. 584.
Naturwissenschaften. Berlin. 2. Jahrgang. 4. Dezember 1914.
Schmidt, Wilhelm. Das Wesen des Donners. p. 1021–1023.
Oesterreichische Flug-Zeitschrift. Wien. 8. Jahrgang. 31. Dezember 1914.
Hörbiger, H. Glacialkosmogonische Beiträge zur Physik der Atmosphäre und der Sonne. p. 396–400.

NOTES FROM THE WEATHER BUREAU LIBRARY.

By C. FITZHUGH TALMAN, Professor in charge of Library.

[Dated, Washington, Mar. 1, 1915.]

INDIAN SUMMER.

In nearly everything that has heretofore been written concerning the expression "Indian summer" it is taken for granted that the term "Indian" used in this connection has reference to the North American Indians. In his memoir published in the MONTHLY WEATHER REVIEW of January and February, 1902, Mr. Albert Matthews quotes some letters of Horace Walpole in which certain unusually hot summers in India are described as "Indian," obviously in allusion to the hot climate of India, or possibly the "Indies" in general; but these quotations probably have no bearing on the history of the term "Indian summer" as now commonly used in America. Somewhat more pertinent is the suggestion of Prof. Abbe [1] that "some early traveler who had been in India and had experienced the dry, hazy weather of the dusty Indian plains recognized the same kind of sky in our Indian summer haze."

Mr. Horace Ware, of Boston, has recently called the writer's attention to the fact that the term "Indian summer" is applied in the British Board of Trade regulations to the season of fine weather over the waters adjacent to British India, and that the abbreviation "I. S.," meaning Indian summer, is used in marking one of the maximum load lines on British ships. The regulations under the merchant shipping act of 1894, adopted January 12, 1899, contain the following provisions as to marking load lines: [2]

3. Such maximum load lines shall be as follows, and the upper edge of such lines shall respectively indicate:

For fresh water: The maximum depth to which the vessel can be loaded in fresh water.

For Indian summer: The maximum depth to which the vessel can be loaded for voyages during the fine season in the Indian seas, between the limits of Suez and Singapore.

For summer: The maximum depth to which the vessel can be loaded for voyages (other than Indian summer voyages) from European and Mediterranean ports between the months of April and September, both inclusive, and as to voyages in other parts of the world (other than Indian summer voyages) the maximum depth to which the vessel can be loaded during the corresponding or recognized summer months.

For winter: The maximum depth to which the vessel can be loaded for voyages (other than Indian summer voyages and summer voyages) from European and Mediterranean ports between the months of October and March, both inclusive, and as to voyages in other parts of the world the maximum depth to which the vessel can be loaded during the corresponding or recognized winter months.

For winter (North Atlantic): The maximum depth to which the vessel can be loaded for voyages to or from the Mediterranean or any European port, from or to ports in British North America or eastern ports in the United States, north of Cape Hatteras, between the months of October and March, both inclusive.

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[1] MONTHLY WEATHER REVIEW, Feb., 1902, 30: 79, footnote 142.
[2] Robt. Temperley. "The Merchant Shipping Acts." London, 1907, pp. 710–711.

Such maximum load lines shall be distinguished by initial letters conspicuously marked opposite such horizontal lines as aforesaid, such initial letters being as follows:

F. W.—Fresh water.
I. S.—Indian summer.
S.—Summer.
W.—Winter.
W. N. A.—Winter, North Atlantic.

The season of fine weather in the Indian seas (i. e., the Arabian Sea, the Bay of Bengal, and adjacent waters) is the period from November to March, inclusive, when the northeast monsoon prevails, or more especially the months January–March, inclusive, when these seas are entirely free from tropical cyclones. Astronomically, this season is "winter" rather than "summer." It is, however, the dry season, and it is not uncommon in tropical countries to identify the dry season with summer and the rainy season with winter. This custom is especially common in Spanish-speaking tropical countries, where the dry season is commonly called "verano" (summer) and the wet season "invierno" (winter), regardless of the ordinary calendar. However, the present writer is not familiar with this use of the terms "summer" and "winter" in literature relating to or emanating from India. Certainly the "winter" of guidebook and travel literature concerning India is the cold season, i. e., January and February.

We should be glad to obtain information as to the history of the term "Indian summer" as applied by British sailors to the season of fine weather in the Indian seas, and also as to the limits of the season thus designated. If the term was current in this sense as early as the eighteenth century, the fact may have some bearing upon the history of the term in its more familiar application to a spell of fine, tranquil weather in autumn, though this does not, at present, seem likely.

SECTION VII.—WEATHER AND DATA FOR THE MONTH.

THE WEATHER OF THE MONTH.

By P. C. DAY, Climatologist and Chief of Division.

Pressure.—The distribution of the mean atmospheric pressure over the United States and Canada, and the prevailing direction of the winds, are graphically shown on Chart VII, while the average values for the month at the several stations, with the departures from the normal, are shown in Tables I and III.

For the month as a whole the barometric pressure was low over nearly all portions of the country, the most marked minus departures occurring in the lower Missouri Valley, Kansas, northern California, and the western portions of Oregon and Washington. The only portions of the country where the pressure averaged above the normal were the New England and Middle Atlantic States, the lower Lake region, western Colorado and northern New Mexico, the plus departures in the northern New England States were rather marked.

The month opened with relatively high pressure over all districts except the upper Lake region and the extreme north Pacific slope where moderately low pressure prevailed. From the 5th–8th a trough of low pressure extending from Canada to northern Texas moved from the Rocky Mountain region eastward, and during the next few days an extensive area of high pressure prevailed over the Central Valleys and to the eastward, which in turn was followed during the first few days of the second decade by another trough of low pressure extending from Canada to the Gulf. A succession of low pressure areas emanating in the extreme Northwest and far Southwest, passed eastward and northeastward, causing nearly continuous cloudy or rainy weather during the greater portion of the last half of the month, throughout the Central Valleys and eastern section of the country.

The distribution of the highs and lows was generally favorable for northerly winds over the northern districts from the Rocky Mountains eastward to the Atlantic, and from a southerly or southeasterly direction over the west Gulf and Pacific Coast States. Elsewhere variable winds prevailed.

Temperature.—With the opening of the year temperatures were near the normal in most districts, with a general tendency to warmer weather. Moderate winter weather continued throughout most of the first decade and the average temperature for this period was normal or above in nearly all districts. Over the Middle Plains region the period was very generally warmer than the average throughout, the excess above the normal being as much as 8° in portions of Kansas.

No decided temperature changes occurred during the second decade until after the middle, when considerably colder weather overspread the central and southern districts and freezing temperatures extended into the Gulf States and portions of the far Southwest, and frosts occurred in northern Florida. Over the northern and central districts, however, from the Rocky Mountains eastward, moderate weather continued, as a rule, and the average temperature for the decade was well above the normal, the excess in some cases amounting to more than 10°.

With the beginning of the third decade a tendency to colder weather was apparent in the western mountain districts, which extended southeastward during the following few days and by the 24th and 25th had overspread the west Gulf States with freezing weather to the coast line. Cold weather continued at the same time over much of the Mountain and Plateau regions, and in the northern districts from the upper Lakes westward.

By the 27th the cold over the Northwest had become severe, the minimum temperature falling to 40° or more below zero at points in North Dakota and Minnesota. This cold wave rapidly overspread the central valleys and Lake region during the following day, with minimum temperatures more than 50° below zero near the northern shore of Lake Superior. During the closing days of the month the cold area extended eastward to the Atlantic coast, but lost much of its severity, except in portions of New England and northern New York, where minimum temperatures from 20° to 30° below zero occurred. Much warmer weather overspread the western districts about the 29th and 30th and at the close of the month the temperatures were above normal over nearly all portions of the country. The average temperatures for the last decade were below normal over the greater part of the country, and over the northern portions from the Lake region to the Rocky Mountains and in the middle Mississippi Valley they were 10° to 15° lower than the normal.

As a whole, the average temperature for the month did not depart greatly from the normal in any district, the large excess in temperature during the first half of the month in some sections being largely or entirely overcome by the severe cold of the latter half.

Day temperatures were moderately high in the far Northwest about the end of the first decade of the month and along the Atlantic coast about the end of the second decade, but no previous high records were broken. In southern Florida only did the maximum temperatures exceed 80°, while at some points in North Dakota they did not go above the freezing point during the month.

Freezing temperatures prevailed at some time during the month over all portions of the country save in central and southern Florida, over southwestern Arizona, and the lower elevations of California, and along the immediate Pacific coast.

Precipitation.—During the first few days of the month generally fair weather prevailed throughout the country save for light snowfall from the region of the Great Lakes eastward and local rains in Florida and along the Pacific coast. However, on the morning of the 5th a trough of low pressure extended from Lake Superior southwestward into New Mexico, and precipitation had set in over the Mountain region of the West, which, during the following day or two, extended over all districts to the eastward. No unusually heavy precipitation occurred in connection with this storm, although some comparatively heavy falls were recorded in the South Atlantic and east Gulf States, also in New York.

With the passing of the storm above referred to, no precipitation of importance occurred until early in the second decade, when snows and rains set in generally over

the eastern half of the country, with heavy rainfall in the Middle and South Atlantic and east Gulf States, accompanying a low-pressure area of considerable energy that moved from the Gulf to New England. From the 15th to the 17th a depression moved from the far Southwest to the upper Lake region, and during the following day or two a second disturbance moved northeastward from the Gulf of Mexico, while still another, following closely in succession, moved from the Northwest to the Ohio Valley, and thence northeastward. As a result of this storm activity general rains and snows continued over practically all eastern districts during the last half of the second decade.

Pressure changes continued rather marked, and stormy weather was prevalent over much of the country during the third decade, and considerable precipitation occurred, especially over eastern districts and the far West. The pressure was particularly low along the Pacific coast near the close of the month, causing unusually heavy falls of rain in southern California and southwestern Arizona, and probably heavy snow in the mountain districts of those and the adjoining States, as the storm passed inland. At the close of the month this disturbance had moved eastward to the Mississippi Valley, attended by snow and sleet in the North Atlantic States and the region of the Great Lakes, snow in the upper Mississippi Valley and middle Plains States, and rain throughout the central and southern districts, while at the same time another storm was approaching the north Pacific coast, accompanied by general rains in the coast States.

The totals for the month were in excess of the normal in most districts from the Plains region eastward, the amounts being particularly heavy over most of the east Gulf and Atlantic coast States, where from 6 to 8 inches occurred. The monthly totals were likewise heavy in California and southwestern Arizona, and were in excess of the normal very generally over the southern Rocky Mountain region also, but in most other districts west of the mountains, as well as in portions of Texas and Oklahoma, the amounts were comparatively small and less than the monthly normals.

Over the central districts east of the Rocky Mountains the monthly amounts ranged from about 1 inch in the central Plains States to 4 or 5 inches over the Appalachian Mountain region, while to the northward they ranged from less than one-half inch in the Dakotas to about 2 inches in the lower Lake region.

Snowfall and ice.—During the first few days of the month there was a general increase of several inches in the depth of snow over the Lake region; elsewhere there was little change until near the end of the first decade, when the warm weather and general rains caused, except in the upper Lake region, a considerable reduction in the snow depth, several inches disappearing from districts in Iowa and southern Minnesota, and eastward to the Lake region, and from central Pennsylvania northeastward to New England.

The storms during the second decade caused an increase in the snow depth over portions of New England, New York, the upper Lake region, and thence westward to the Dakotas, and from Iowa southwestward to southern Kansas. Likewise there was a considerable increase in the depth over the Mountain and Plateau regions of the West.

The third decade was, as a whole, stormy and the heaviest general snowfall probably occurred in connection with the storm that moved from the central Rocky Mountain region southeastward to the Mississippi Valley and thence to the Lake regions, on the 21st and 22d. During this time snow fell over nearly all central and northern districts from the Rocky Mountains eastward, except near the middle Atlante coast, causing a considerable increase in the depth from the middle Mississippi Valley eastward over the northern drainage of the Ohio and in the lower Lake regions, locally in Montana and Wyoming, and over the eastern slopes of the Rocky Mountains from Colorado northward. Elsewhere in the mountain districts of the West there was little snowfall during this period.

Although temperature changes were frequent during the month they caused little variations in ice thickness until near the close, when a severe cold wave caused an increase in the thickness over all districts from which ice was reported.

At the close of the month the Missouri River was gorged at St. Joseph, and heavily ice covered from thence to its source. Likewise in the Mississippi there was ice as far south as Cairo, and the upper portions of the river were icebound. Practically no ice had formed in the Ohio, and none on the main streams of the Atlantic coast south of the Hudson, while in New England practically all streams were icebound.

GENERAL SUMMARY.

Unlike the preceding month, January, 1915, was nearly uniformly warm and pleasant during the first half of the month and favorable for such farming and other operations as are possible during the winter season. The latter part of the month, however, was moderately cold, especially over the northern districts, and there was much cloudy weather with frequent rains and considerable snow in the central and eastern portions of the country as well as in the far Southwest and over the middle and southern Pacific coasts.

Maximum wind velocities, January, 1915.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
		Mi./hr.				*Mi./hr.*	
Block Island, R. I.	12	74	ne.	Norfolk, Va.	13	64	nw.
Do	13	72	ne.	....do	20	57	w.
Buffalo, N. Y.	2	60	w.	North Head, Wash.	2	64	se.
Do	7	80	sw.	....do	7	50	s.
Do	8	56	sw.	....do	10	74	se.
Do	19	63	sw.	....do	11	62	se.
Do	23	54	sw.	....do	13	60	se.
Do	29	50	sw.	....do	14	60	nw.
Canton, N. Y.	7	53	w.	....do	15	54	nw.
Do	19	56	sw.	Philadelphia, Pa.	12	60	ne.
Cheyenne, Wyo.	12	66	w.	....do	13	51	ne.
Do	13	60	w.	Pt. Reyes Light	5	50	s.
Do	14	58	w.	....do	8	70	nw.
Detroit, Mich.	7	50	nw.	....do	11	59	sw.
Duluth, Minn.	17	58	nw.	....do	14	54	nw.
Eastport, Me.	13	51	ne.	....do	15	62	nw.
El Paso, Tex.	15	56	sw.	....do	27	62	s.
Galveston, Tex.	31	64	s.	....do	28	61	s.
Hatteras, N. C.	12	53	w.	....do	31	50	s.
Do	12	56	w.	Providence, R. I.	13	60	ne.
Mt. Tamalpais, Cal.	8	60	nw.	Sand Key, Fla.	11	50	w.
Do	11	54	sw.	Sandy Hook, N. Y.	7	64	se.
Do	14	54	nw.	....do	12	74	ne.
Do	15	51	ne.	....do	13	70	ne.
Do	16	58	n.	....do	19	50	s.
Nantucket, Mass.	12	65	ne.	Tatoosh Island, Wash.	5	53	e.
Do	13	78	ne.				
New Haven, Conn.	13	53	ne.	....do	14	54	w.
New Orleans, La.	31	51	se.	....do	20	54	e.
New York, N. Y.	3	66	nw.	....do	21	60	e.
Do	6	60	se.	....do	27	55	e.
Do	7	84	s.	....do	29	60	e.
Do	12	56	ne.	Toledo, Ohio	7	51	sw.
Do	13	60	n.	Trenton, N. J.	6	52	se.
Do	18	51	s.	....do	12	70	ne.
Do	21	54	nw.	....do	13	62	ne.
Do	23	50	sw.				

In the winter-grain-growing States the ground was largely snow covered, especially during the colder weather of the latter half of the month, and wheat and other grains as well as young clover were well protected thereby. The snow fell as a rule without serious drifting and on melting should furnish an excellent supply of moisture for the growing plants.

In the trucking regions of the South cold weather delayed growth somewhat, and in most sections outdoor work was much delayed by the wet condition of the soil. No serious damage to fruit or truck occurred on account of frost, but the continued wet weather was unfavorable.

On the great cattle ranges of the West the weather was mostly favorable and stock was reported as in good condition, and on account of the absence of deep snow ranges continued to furnish feed in many sections.

In the mountain regions of the West the deficiency in the snowfall over the northern districts continued, and the amount stored in the high ranges is still much below the normal. In the mountains of California and in portions of Oregon, Arizona, New Mexico, and Utah there was considerable snow, and there were unusually heavy rains in southern California and the lower elevations of Arizona and western New Mexico. These have added very materially to the water supply and greatly improved the outlook for the coming crop season.

In California a good crop of citrus fruits was harvested.

Average accumulated departures for January, 1915.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	°F.	°F.	°F.	Ins.	Ins.	Ins.			P. ct.	P. ct.
New England	28.9	+4.5	......	5.55	+2.10	......	6.3	+0.4	79	+ 3
Middle Atlantic	34.7	+3.1	......	5.14	+1.90	......	7.0	+1.2	78	+ 2
South Atlantic	45.5	+1.3	......	5.62	+1.70	......	7.8	+2.5	77	0
Florida Peninsula	63.7	0.0	......	5.39	+2.70	......	6.8	+2.0	80	− 1
East Gulf	46.7	−0.7	......	7.14	+2.10	......	5.8	+0.1	76	− 2
West Gulf	46.1	−0.1	......	2.60	−0.30	......	5.8	+0.5	74	− 2
Ohio Valley and Tennessee	32.7	−0.5	......	4.67	+0.80	......	7.2	+0.8	79	+ 2
Lower Lakes	24.6	+0.3	......	3.25	+0.60	......	7.4	0.0	81	0
Upper Lakes	18.2	0.0	......	1.72	−0.20	......	7.5	+0.6	83	0
North Dakota	6.3	+2.2	......	0.23	−0.40	......	5.9	+1.0	84	+ 4
Upper Mississippi Valley	20.8	−0.7	......	2.08	+0.40	......	6.3	+0.9	83	+ 5
Missouri Valley	22.6	+1.6	......	1.61	+0.60	......	5.7	+0.7	82	+ 7
Northern slope	19.7	+0.7	......	0.72	−0.60	......	5.8	+0.7	75	+ 5
Middle slope	30.8	+1.8	......	0.85	+0.10	......	4.8	+0.7	71	+ 4
Southern slope	40.4	−1.1	......	1.02	+0.30	......	4.3	−0.1	66	0
Southern Plateau	37.6	−3.1	......	1.66	+0.90	......	4.0	+0.6	64	+14
Middle Plateau	26.2	−1.6	......	0.82	−0.20	......	5.6	+0.5	71	+ 1
Northern Plateau	27.3	−1.5	......	0.80	−0.80	......	7.4	+0.7	78	− 2
North Pacific	40.7	+1.3	......	5.39	−1.30	......	7.2	−0.3	83	− 2
Middle Pacific	47.5	+0.3	......	7.41	+2.70	......	6.3	+0.7	79	− 2
South Pacific	52.5	+1.6	......	5.06	+2.30	......	5.2	+0.7	72	0

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data, as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Summary of temperature and precipitation by sections, January, 1915.

Section.	Temperature (° F.).								Precipitation (in inches and hundredths).					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
Alabama	43.8	−1.7	Selma	81	31	Hamilton	15	26	6.15	+1.80	Bermuda	10.40	Mentone	3.18
Arizona	41.0	−2.2	Parker	76	16	Chin Lee	−20	17	2.29	+1.28	Pinal Ranch	6.20	2 stations	0.70
Arkansas	39.3	−1.2	Portland	74	14	Pond	− 3	28	4.38	+0.21	Lake Farm	6.95	Rogers	1.28
California	44.2	−1.6	King City	89	12†	Tamarack	−20	8	7.58	+2.17	Magalia	28.40	Mammoth Tank	0.11
Colorado	20.9	−2.9	Hoehne	73	30	Gunnison	−38	23†	0.97	−0.09	Savage Basin	5.60	3 stations	T.
Florida	57.7	−0.4	5 stations	83	18†	3 stations	25	1†	5.56	+2.78	Monticello	12.24	Clermont	1.43
Georgia	45.9	−0.3	Valdosta	81	31	2 stations	17	21	6.02	+2.21	Valdosta	11.30	Savannah	3.58
Hawaii (for December)	68.6	......	3 stations	87	1†	Schofield Barracks.	41	20	9.45	....	Hakalau, Hawaii	59.81	Ewa Mill, Oahu	2.74
Idaho	22.5	−2.4	Hotspring	56	31	stations	−33	22†	1.31	−1.09	Sheep Hill	3.81	Challis	0.21
Illinois	23.6	−3.1	White Hall	60	16	Montrose	−29	24	2.56	+0.18	Golconda	7.45	Dixon	1.11
Indiana	25.6	−3.5	2 stations	58	16	Veedersburg	−27	24	3.39	+0.34	Evansville	6.65	Collegeville	1.50
Iowa	17.5	−0.4	Keokuk	59	16	Iowa Falls	−32	28	1.63	+0.58	Tipton	3.15	Rock Rapids	0.10
Kansas	29.4	−0.2	2 stations	66	12†	2 stations	−22	28	1.26	+0.58	2 stations	3.05	Coolidge	T.
Kentucky	33.0	−2.4	3 stations	65	17†	2 stations	0	26	5.04	+0.82	Alpha	6.74	Williamstown	3.50
Louisiana	48.1	−2.9	Opelousas	84	9	Antioch	17	25	6.88	+2.24	Lake Charles	11.10	Logansport	3.22
Maryland and Delaware	34.1	+1.1	Millsboro, Del	67	7	Deer Park, Md	−10	29	5.86	+2.50	State Sanitorium, Md	8.41	Solomons, Md	3.38
Michigan	19.1	−1.0	Mount Clemens	55	11	Humboldt	−48	28	1.70	−0.39	Victoria	3.79	Charlotte	0.50
Minnesota	8.4	+0.2	Grand Marais	50	3	Winton	−48	28	0.69	−0.02	Cloquet	2.06	Halstad	T.
Mississippi	44.0	−2.4	Fayette	76	14	2 stations	15	24†	6.55	+1.52	Magnolia	10.43	Yazoo City	3.66
Missouri	29.1	−2.2	Hollister	76	15	Louisiana	−24	24	2.92	+0.59	Caruthersville	5.81	Tarkio	1.48
Montana	20.1	+1.4	Lytle	69	18	Medicine Lake	−47	25	0.61	−0.28	Hebgen Dam	2.64	Wibaux	T.
Nebraska	20.1	−1.6	2 stations	63	12	Broken Bow	−42	23	1.07	+0.50	Falls City	4.63	Wauneta	0.05
Nevada	30.2	+0.5	Jean	78	14	Tecoma	−25	23	0.68	−0.68	Searchlight	2.46	2 stations	T.
New England	25.8	+4.2	Cornish, Me	62	7	Bloomfield, Vt	−38	30	5.32	+1.74	Kingston, R. I	11.43	Burlington, Vt	1.16
New Jersey	33.5	+3.5	Lambertville	61	19	Culvers Lake	− 5	30	6.55	+2.74	Lakewood	8.92	Cape May	4.40
New Mexico	29.7	−4.8	2 stations	71	20†	Regina	−25	17	0.91	+0.31	Noria	4.05	Richland	T.
New York	24.9	+2.5	Troy	60	7	Gabriels	−38	30	4.45	+1.49	Lake Grove	11.67	Chazy	0.88
North Carolina	41.0	+0.4	2 stations	74	6†	2 stations	3	21†	6.26	+2.49	Highlands	13.27	Hot Springs	1.34
North Dakota	5.6	+0.4	McLeod	51	4	Langdon	−48	27	0.32	−0.17	Forman	1.25	2 stations	0.00
Ohio	26.3	−1.6	Portsmouth	64	16	3 stations	−22	24	3.40	+0.36	Thurman	5.50	Hillhouse	2.08
Oklahoma	37.5	−1.1	Tahlequah	77	16	Buffalo	− 2	23	1.20	+0.05	Idabel	4.01	Canton	0.10
Oregon	33.1	−0.8	Brookings	67	28	Sunrise Valley	−26	22	3.91	−1.30	Happy Home	19.73	Whitaker	T.
Pennsylvania	28.3	+0.6	3 stations	62	7†	Saegerstown	−26	30	5.56	+2.08	Hamburg	9.69	Erie	2.43
Porto Rico	73.7	+0.5	Naguabo	98	30	2 stations	50	14†	3.56	−0.06	Rio Grande (El Verde).	13.25	Sabana Grande	0.02
South Carolina	45.1	−0.3	Yemassee	76	7	Greenville	19	21	6.31	+2.89	Georgetown	9.53	Darlington	3.15
South Dakota	14.7	−0.9	Ardmore	61	4	2 stations	−40	25	0.98	+0.10	Hardy Ranger Station.	5.50	Sioux Falls	0.03
Tennessee	37.2	−1.2	2 stations	70	31	Mountain City	3	22	5.47	+1.19	Graysville	8.51	Elizabethton	2.09
Texas	46.1	−2.1	Llano Grande	87	30†	2 stations	− 1	24	1.97	+0.55	Port Arthur	7.35	2 stations	0.02
Utah	22.7	−4.6	Springdale	64	3	Scofield	−25	23	1.15	−0.18	Leeds	3.80	Manila	T.
Virginia	36.5	+1.3	Callaville	69	6	Burkes Garden	− 5	22	5.21	+2.08	Swetnam	7.88	Speers Ferry	3.27
Washington	30.7	−0.6	Quiniault	64	29	Ellensburg	−17	26	3.60	−0.67	Lake Cushman	17.99	Sullivan Lake	0.17
West Virginia	31.7	−1.0	2 stations	68	16	New Cumberland	− 8	30	4.85	+1.01	Pickens	11.38	Burlington	2.00
Wisconsin	13.1	−1.0	Mauston	48	16	Winter	−52	28	1.42	+0.20	High Falls	2.35	Hatfield	0.60
Wyoming	19.0	−1.9	2 stations	60	12	Upton	−45	23	0.82	−0.19	Upper Basin	3.30	Powell	T.

† Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

Table I gives the data ordinarily needed for climatological studies for about 158 Weather Bureau stations making simultaneous observations at 8 a. m. and 8 p. m., seventy-fifth meridian time daily, and for about 41 others making only one observation. The altitudes of the instruments above ground are also given.

Tabie II gives a record of precipitation, the intensity of which at some period of the storm's continuance equaled or exceeded the following rates:

Duration (minutes)	5	10	15	20	25	30	35	40	45	50	60
Rates per hour (inches)	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.87	0.84	0.80

It is impracticable to make this table sufficiently wide to accommodate on one line the record of accumulated falls that continue at an excessive rate for several hours. In this case *the record is broken at the end of each 50 minutes*, the accumulated amounts being recorded on successive lines until the excessive rate ends.

In cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred, the greatest precipitation of any single storm has been given, also the greatest hourly fall during that storm.

Table III gives, for about 30 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values, except in the case of snowfall.

Chart I.—Hydrographs for several of the principal rivers of the United States.

Chart II.—Tracks of centers of high areas; and

Chart III.—Tracks of centers of low areas. The roman numerals show the chronological order of the centers. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the observations at 8 a. m. and 8 p. m., 75th meridian time. Within each circle is also given (Chart II) the last three figures of the highest barometric reading and (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sea level and standard gravity.

Chart IV.—Temperature departures. This chart presents the departures of the monthly mean temperatures from the monthly normals. The normals used in computing the departures were computed for a period of 33 years (1873 to 1905) and are published in Weather Bureau Bulletin "R," Washington, 1908. Stations whose records were too short to justify the preparation of normals in 1908, have been provided with normals as adequate records became available and all have been reduced to the 33-year interval 1873–1905. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July, 1909.

Chart V.—Total precipitation. The scale of shades showing the depth is given on the chart. Where the monthly amounts are too small to justify shading, and over sections of the country where stations are too widely separated or the topography is too diversified to warrant reasonable accuracy in shading, the actual depths are given for a limited number of representative stations. Amounts less than 0.005 inch are indicated by the letter T, and no precipitation by 0.

Chart VI.—Percentage of clear sky between sunrise and sunset. The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the nighttime.

Chart VII.—Isobars and isotherms at sea level and prevailing wind directions. The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow on pages 13–16 of the REVIEW for January, 1902. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of the 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observations, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in the Annual Report of the Chief of the Weather Bureau, 1900–1901, volume 2, Table 27, pages 140–164.

The isotherms on the sea-level plane have been constructed by means of the data summarized in chapter 8 of volume 2, of the annual report just mentioned. The correction t_0-t, or temperature on the sea-level plane minus the station temperature as given by Table 48 of that report, is added to the observed surface temperature to obtain the adopted sea-level temperature.

The prevailing wind directions are determined from hourly observations at the great majority of the stations; a few stations having no self-recording wind direction apparatus determine the prevailing direction from the daily or twice-daily observations only.

Chart VIII.—Total snowfall. This is based on the reports from regular and cooperative observers and shows the depth in inches and tenths of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures are also given.

Chart VIII is published only when the general snow cover is sufficiently extensive to justify its preparation.

[Charts XLIII–9—XLIII–23 illustrate the paper by C. F. Brooks on the Snowfall of the eastern United States.]

TABLE I.—*Climatological data for United States Weather Bureau stations, January, 1915.*

Districts and stations.	Elevation of instruments. Barometer above sea level, feet.	Elevation of instruments. Thermometer above ground.	Elevation of instruments. Anemometer above ground.	Pressure in inches. Station, reduced to mean of 24 hours.	Pressure in inches. Sea level, reduced to mean of 24 hours.	Pressure in inches. Departure from normal.	Temperature. Mean max. + mean min. ÷ 2.	Temperature. Departure from normal.	Temperature. Maximum.	Temperature. Date.	Temperature. Mean maximum.	Temperature. Minimum.	Temperature. Date.	Temperature. Mean minimum.	Temperature. Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Days with 0.01 or more.	Wind. Total movement, miles.	Wind. Prevailing direction.	Wind. Maximum velocity. Miles per hour.	Wind. Maximum velocity. Direction.	Wind. Maximum velocity. Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
New England.							**28.9**	**+ 4.5**										**79**	**5.55**	**+ 2.1**										**6.3**		
Eastport	76	67	85	30.02	30.11	+0.11	24.6	+ 4.5	47	19	32	− 9	30	18	41	22	18	76	5.80	+ 2.0	15	9,840	w.	51	ne.	13	7	9	15	6.8	12.2	1.0
Greenville	1,070	6	....	28.88	30.10	......	16.4	......	49	7	26	−18	30	6	37				2.22		10									....	15.6	10.0
Portland, Me	103	82	117	30.00	30.13	+ .08	26.4	+ 4.4	58	7	33	− 5	30	19	26	23	18	72	6.00	+ 2.2	14	6,164	n.	42	s.	7	14	5	12	5.4	19.0	13.4
Concord	288	70	79	29.81	30.14	+ .09	25.1	+ 3.9	57	7	34	−13	3	16	41	....	....	....	3.47	+ 0.1	10	3,245	nw.	24	nw.	24	10	7	14	5.9	13.4	10.0
Burlington	404	11	48	29.65	30.12	+ .07	21.9	+ 5.6	51	7	30	−18	30	14	30	....	....	....	1.16	− 0.7	11	9,039	s.	43	s.	7	3	12	16	6.9	8.9	4.5
Northfield	876	12	60	29.13	30.12	+ .07	18.4	+ 3.3	50	7	29	−28	30	8	43	16	14	87	2.56	+ 0.1	12	4,892	s.	31	s.	7	6	9	16	6.6	15.2	10.0
Boston	125	115	188	29.97	30.11	+ .06	33.0	+ 6.0	62	7	40	3	30	27	33	30	25	74	6.33	+ 2.5	11	7,951	nw.	42	n.	13	12	3	16	5.8	7.0	2.3
Nantucket	12	14	90	30.08	30.09	+ .05	35.6	+ 3.5	54	19	41	16	30	30	28	33	31	84	6.34	+ 2.9	17	12,860	n.	78	ne.	13	6	7	18	7.4	6.6	2.0
Block Island	26	11	46	30.06	30.09	+ .02	34.6	+ 3.2	54	19	40	13	30	30	29	33	30	82	8.25	+ 4.4	14	14,123	n.	74	ne.	12	9	7	15	6.5	4.3	1.2
Narragansett Pier	....	9	....	....	....	....	32.2	+ 3.8	53	19	39	7	31	25	29	....	....	....	8.97	......	14		nw.	....	....	....	15	3	13	....	9.0	3.0
Providence	160	215	251	29.93	30.11	+ .05	31.8	+ 4.6	58	7	38	5	30	26	31	30	26	82	6.86	+ 2.5	14	9,365	nw.	60	ne.	13	13	3	15	5.7	8.8	3.5
Hartford	159	122	140	29.93	30.11	+ .04	30.6	+ 5.1	57	7	37	9	5	24	31	28	24	78	5.70	+ 1.9	13	5,024	n.	40	sw.	7	6	11	14	6.6	7.4	4.1
New Haven	106	117	155	29.98	30.10	+ .02	33.0	+ 5.7	57	7	39	11	30	27	25	29	24	73	8.59	+ 4.7	15	7,029	n.	53	ne.	13	12	4	15	6.0	8.2	3.2
Middle Atlantic States.							**34.7**	**+ 3.1**										**78**	**5.14**	**+ 1.9**										**7.0**		
Albany	97	102	115	30.02	30.13	+ .06	27.3	+ 4.8	56	7	34	− 3	30	20	33	25	22	81	2.76	+ 0.2	13	5,839	s.	33	se.	7	8	7	16	6.5	8.2	1.4
Binghamton	871	10	69	29.14	30.10	+ .02	27.8	+ 4.7	54	19	35	3	5	20	35	....	....	....	4.33	+ 2.4	15	4,435	nw.	24	sw.	19	6	7	18	7.1	13.7	1.9
New York	314	414	454	29.75	30.10	.00	34.1	+ 3.9	57	19	40	10	30	28	23	31	26	72	5.61	+ 1.8	17	13,038	nw.	84	s.	7	10	5	16	6.5	4.0	0.9
Harrisburg	374	94	104	29.72	30.14	+ .04	32.2	+ 3.5	61	19	38	11	29	26	27	28	24	75	6.04	+ 3.2	15	5,157	e.	32	s.	7	10	9	12	5.8	9.5	2.0
Philadelphia	117	123	190	29.99	30.12	+ .01	36.6	+ 4.8	61	18	43	14	30	30	23	34	30	79	6.74	+ 3.3	13	8,586	nw.	60	ne.	12	11	6	14	6.0	2.1	0.5
Reading	325	81	98	29.76	30.13	......	33.2	......	62	19	40	11	30	26	29	30	26	78	6.51	+ 3.0	14	5,579	nw.	37	ne.	12	7	9	15	6.4	4.0	0.4
Scranton	805	111	119	29.23	30.12	+ .03	30.2	+ 4.7	61	19	38	5	30	23	29	27	24	80	4.09	+ 1.3	14	4,790	nw.	32	sw.	19	4	9	18	7.7	8.6	2.3
Atlantic City	52	37	48	30.05	30.11	.00	35.9	+ 3.4	59	7	42	15	30	30	23	33	30	82	5.28	+ 1.9	12	6,192	nw.	45	ne.	13	9	9	13	6.1	0.3	....
Cape May	18	13	49	30.11	30.13	+ .01	36.4	+ 2.3	58	7	42	16	30	31	21	....	....	....	4.40	+ 1.0	14	6,934	n.	48	e.	12	10	8	13	5.9	1.2	....
Sandy Hook	22	10	57	30.09	30.11	......	34.6	......	56	19	40	14	30	30	20	33	30	86	6.44	......	13	12,288	nw.	74	ne.	12	9	8	14	6.4	0.5	T.
Trenton	190	159	183	29.89	30.10	......	34.0	......	60	18	41	12	30	27	27	31	28	79	5.15	+ 2.0	15	8,803	nw.	70	ne.	12	9	9	13	6.1	2.4	0.4
Baltimore	123	100	113	29.99	30.13	+ .01	36.0	+ 2.6	58	7	42	16	30	30	21	32	28	76	6.81	+ 3.6	14	4,982	n.	43	n.	13	9	9	13	5.8	2.5	0.5
Washington	112	62	85	29.99	30.12	− .01	35.6	+ 2.7	63	18	43	18	30	28	27	32	28	76	6.34	+ 3.0	14	5,033	nw.	46	nw.	13	10	7	14	5.8	2.0	0.3
Lynchburg	681	153	188	29.34	30.11	− .02	38.4	+ 2.6	66	18	47	20	1	30	30	33	28	74	3.86	+ 0.1	13	5,035	nw.	40	nw.	13	9	9	13	6.3	2.2	1.2
Norfolk	91	170	205	30.02	30.12	− .01	42.2	+ 1.8	66	6	50	25	2	35	29	39	35	77	5.66	+ 2.3	13	10,300	n.	64	nw.	13	9	8	14	5.8	T.	....
Richmond	144	11	52	29.97	30.13	.00	39.4	+ 1.4	65	18	47	23	22	32	28	35	31	79	5.41	+ 2.4	12	5,893	nw.	49	nw.	13	13	5	13	5.3	0.2	....
Wytheville	2,293	40	47	27.65	30.12	− .02	33.2	+ 0.2	63	18	41	10	22	25	30	30	27	82	3.21	− 1.1	12	4,155	w.	26	w.	19	10	5	16	5.9	4.6	1.0
South Atlantic States.							**45.5**	**+ 1.3**										**77**	**5.62**	**+ 1.7**										**7.8**		
Asheville	2,255	70	84	27.69	30.13	− .02	37.0	+ 1.6	60	15	45	19	20	29	31	33	29	79	3.41	− 1.3	15	6,707	nw.	35	nw.	13	8	10	13	6.0	0.8	....
Charlotte	773	68	76	29.25	30.11	− .04	41.6	+ 1.2	62	18	50	23	21	34	26	36	31	73	5.67	+ 1.4	8	5,166	ne.	40	sw.	6	7	10	14	6.2	T.	....
Hatteras	11	12	50	30.09	30.10	− .04	48.1	+ 2.3	70	18	54	31	2	42	25	44	41	81	6.05	+ 1.1	11	13,244	n.	56	w.	13	11	6	14	5.5	....	....
Manteo	12	4	46	....	....	....	44.4	......	68	17	54	22	11	35	....	....	....	....	6.88	+ 2.2	6	......	ne.	....	....	....	16	5	10	....	....	....
Raleigh	376	103	110	29.70	30.12	− .01	42.2	+ 1.8	66	6	50	23	22	34	27	36	32	74	5.06	+ 1.5	9	6,054	ne.	33	w.	6	12	6	13	5.5	T.	....
Wilmington	78	81	91	30.03	30.12	− .02	47.6	+ 2.0	69	23	56	27	22	39	29	42	38	76	8.41	+ 4.9	9	6,120	w.	30	s.	6	14	7	10	5.1	....	....
Charleston	48	11	92	30.05	30.10	− .05	49.7	+ 0.4	67	31	57	32	21	43	24	45	42	80	7.44	+ 4.0	12	7,559	ne.	30	sw.	18	12	3	16	5.9	....	....
Columbia, S. C	351	41	57	29.72	30.12	− .03	45.4	+ 0.3	65	6	54	27	21	36	28	40	35	73	6.02	+ 2.7	10	5,108	ne.	32	sw.	20	13	4	14	5.4	....	....
Augusta	180	89	97	29.92	30.12	− .04	46.4	+ 0.5	70	31	56	28	21	37	31	41	38	80	5.21	+ 1.1	7	4,465	ne.	29	w.	20	9	6	16	6.4	....	....
Savannah	65	150	194	30.03	30.10	− .05	51.2	+ 1.3	70	23	59	32	21	44	24	46	42	79	3.58	+ 0.4	9	7,903	ne.	42	w.	12	10	5	16	6.3	....	....
Jacksonville	43	96	129	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	4.10	+ 1.0	9	......	ne.	....	....	....	8	8	15	6.2	....	....
Florida Peninsula.							**63.7**	**0.0**										**80**	**5.39**	**+ 2.7**										**6.8**		
Key West	22	10	64	30.00	30.02	− .08	69.5	+ 0.7	82	18	74	53	14	65	15	64	62	82	7.65	+ 5.7	14	9,723	ne.	44	nw.	12	9	9	13	6.0	....	....
Miami	25	71	79	30.03	30.06	......	67.0	− 0.3	78	6	72	45	13	62	20	62	60	79	3.64	+ 0.2	14	8,846	nw.	35	w.	12	4	5	2	8.2	....	....
Sand Key	23	39	72	29.98	30.01	− .09	70.0	......	79	6	73	59	14	67	13	67	65	85	7.49	......	12	15,546	ne.	50	w.	11	9	9	13	6.3	....	....
Tampa	35	79	96	30.04	30.08	− .04	59.0	+ 1.6	78	31	67	41	2	51	27	53	49	76	4.89	+ 2.1	9	5,815	ne.	30	sw.	18	7	3	21	7.0	....	....
Titusville	44	6	....	30.07	30.06	......	59.3	− 1.8	77	24	67	38	13	52	28	....	....	....	4.47	......	15	......	n.	....	....	....	8	7	16	6.7	....	....
East Gulf States.							**46.7**	**− 0.7**										**76**	**7.14**	**+ 2.1**										**5.8**		
Atlanta	1,174	190	216	28.84	30.10	− .05	41.9	− 0.3	64	15	49	22	21	35	29	38	32	72	6.19	+ 0.9	10	9,122	nw.	44	nw.	12	11	5	15	6.0	T.	....
Macon	370	78	87	29.70	30.10	− .06	45.7	+ 0.1	73	31	55	27	29	36	35	41	37	79	5.54	+ 0.4	9	4,500	nw.	28	nw.	12	13	4	14	5.6	....	....
Thomasville	273	8	57	29.79	30.10	− .06	51.0	0.0	75	31	61	29	2	41	35	45	42	83	9.70	+ 5.6	9	4,238	nw.	38	sw.	18	12	4	15	5.5	....	....
Pensacola	56	140	182	30.03	30.09	− .05	51.0	− 1.3	67	6	58	32	26	44	27	46	42	76	8.31	+ 4.3	10	10,939	ne.	48	se.	31	9	9	13	6.1	....	....
Anniston	741	9	57	29.31	30.12	− .04	42.4	+ 0.2	67	31	52	22	21	33	30	....	....	....	4.61	− 0.7	12	5,134	se.	29	se.	10	10	7	14	5.9	T.	....
Birmingham	700	11	48	29.33	30.12	− .04	42.8	− 2.5	66	31	51	22	26	35	27	37	32	70	6.44	+ 1.1	10	5,845	nw.	37	se.	11	9	8	14	6.1	T.	....
Mobile	57	125	161	30.02	30.08	− .07	49.6	− 0.2	73	6	58	31	25	41	26	44	40	75	7.54	+ 2.7	9	7,895	n.	43	se.	31	9	10	12	5.4	....	....
Montgomery	223	100	112	29.86	30.11	− .05	46.4	− 1.3	71	31	55	30	26	38	32	41	35	70	8.95	+ 3.8	11	5,212	nw.	27	nw.	12	8	10	13	5.9	T.	....
Meridian	375	85	93	29.69	30.10	− .06	44.8	− 0.2	67	6	54	24	25	36	29	40	35	75	6.77	+ 1.2	12	4,427	ne.	32	se.	10	9	11	11	6.0	0.5	....
Vicksburg	247	65	74	29.81	30.10	− .05	46.3	− 0.7	68	31	54	23	25	38	26	41	36	75	6.06	+ 0.4	15	6,039	se.	33	w.	31	10	7	14	5.9	0.1	....
New Orleans	51	90	121	30.02	30.08	− .05	51.8	− 1.2	74	16	60	31	25	44	29	47	44	80	8.42	+ 3.8	8	6,987	nw.	51	se.	31	10	5	16	5.7	....	....
West Gulf States.							**46.1**	**− 0.1**										**74**	**2.60**	**− 0.3**										**5.8**		
Shreveport	249	77	93	29.81	30.09	− .05	45.2	− 0.1	68	14	54	24	25	36	33	40	35	73	4.22	− 0.2	13	5,774	se.	29	w.	31	10	5	16	5.9	3.0	....
Bentonville	1,303	11	44	28.63	30.04	− .10	35.0	+ 0.9	64	15	45	6	23	26	36	....	....	....	2.12	− 0.5	11	4,523	se.	26	s.	15	9	6	16	6.3	1.7	....
Fort Smith	457	79	94	29.56	30.06	− .08	38.6	+ 0.3	70	15	47	14	23	30	34	34	29	74	2.66	+ 0.2	10	7,296	e.	40	w.	16	8	4	19	6.7	3.9	....
Little Rock	357	139	147	29.70	30.09	− .06	40.2	− 0.4	65	15	48	17	24	32	32	36	32	74	4.62	− 0.2	10	6,742	e.	34	w.	31	9	9	13	6.1	7.0	....
Brownsville	57	3	40	....	....	....	58.8	......	76	30	68	30	25	50	34	....	....	....	3.35	......	7	......	s.	....	....	....	....	....	....	....	....	....
Corpus Christi	20	69	77	30.04	30.06	− .04	54.4	+ 0.9	74	31	62	31	24	47	31	50	47	82	1.36	− 0.9	9	7,770	n.	40	n.	23	5	11	15	6.7	....	....
Dallas	512	109	117	29.51	30.07	......	45.0	......	68	30	55	20	23	36	36	....	....	....	2.17	......	11	7,701	se.	34	se.	30	11	9	11	5.3	0.8	....
Fort Worth	670	106	114	29.31	30.04	− .08	45.4	+ 1.1	72	30	55	21	23	36	35	30	33	67	1.32	+ 0.4	10	8,375	s.	40	w.	30	13	6	12	5.3	0.1	....
Galveston	54	106	114	30.02	30.08	− .05	51.2	− 1.5	65	31	56	31	24	47	21	48	45	83	4.52	+ 0.9	14	8,881	e.	64	s.	31	11	7	13	5.5	....	....
Houston	138	111	121	29.92	30.07	......	51.3	− 1.6	74	14	60	28	24	43	33	....	....	....	2.22	......	11	6,546	se.	31	se.	15	9	10	12	5.9	....	....
Palestine	510	64	72	29.51	30.06	− .06	47.3	+ 0.8	71	15	56	24	23	38	33	42	38	78	3.04	− 0.8	11	5,296	s.	34	s.	15	12	6	13	5.4	0.5	....
San Antonio	701	109	132	29.32	30.06	− .04	50.6	− 0.5	76	14	61	27	18	40	34	44	37	65	0.53	− 1.2	10	6,874	ne.	35	ne.	23	12	6	13	5.3	....	....
Taylor	582	55	63	29.48	30.10	− .01	47.4	− 0.1	71	15	58	24	18	37	34	....	....	....	1.66	− 1.2	11	6,989	s.	34	se.	15	9	14	8	5.3	1.3	....

TABLE I.—*Climatological date for United States Weather Bureau stations, January, 1915*—Continued.

Districts and stations.	Elevation of instruments.			Pressure in inches.			Temperature of the air, in degrees Fahrenheit.												Precipitation, inches.			Wind.									
	Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Total.	Departure from normal.	Days with 0.01 or more.	Total movement, miles.	Prevailing direction.	Maximum velocity: Miles per hour.	Maximum velocity: Direction.	Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
Ohio Valley and Tennessee.							**32.7**	**− 0.5**										**79**	**4.67**	**+ 0.8**										**7.2**		
Chattanooga	762	189	213	29.30	30.13	− .03	40.6	− 0.0	62	16	48	22	21	33	26	35	30	69	5.73	+ 0.2	13	6,014	nw.	46	w.	18	6	5	20	6.8	0.4	....
Knoxville	996	93	100	29.02	30.10	− .05	38.8	+ 1.3	67	31	46	22	1	31	30	35	31	76	4.18	− 0.8	12	3,781	ne.	25	s.	31	5	8	18	7.2	1.0	....
Memphis	399	76	97	29.68	30.12	− .04	39.4	− 0.9	65	15	46	17	24	33	27	35	30	69	5.69	+ 0.5	12	6,552	n.	38	w.	6	9	4	18	6.7	3.6	....
Nashville	546	168	191	29.53	30.13	− .03	36.2	− 1.8	63	31	44	16	24	28	28	33	30	80	5.89	+ 1.0	15	7,148	nw.	46	se.	31	6	4	21	7.3	2.5	....
Lexington	989	75	102	29.18	30.11	− .02	32.0	− 1.0	59	16	39	8	24	25	27	....	....	....	4.38	+ 0.6	16	7,597	w.	36	se.	22	5	11	15	6.9	7.3	T.
Louisville	525	219	255	29.52	30.12	− .02	31.9	− 2.4	58	16	39	4	24	24	28	30	28	86	4.98	+ 1.1	13	8,238	se.	36	sw.	1	4	7	20	7.6	7.0	T.
Evansville	431	72	82	29.62	30.11	− .03	31.5	− 0.8	56	16	39	4	24	24	23	28	25	80	6.65	+ 3.0	11	5,082	nw.	30	s.	16	7	6	18	6.9	17.2	....
Indianapolis	822	154	164	29.18	30.10	− .02	26.8	− 1.4	53	16	34	− 7	24	19	25	24	21	82	3.31	+ 0.5	12	7,236	sw.	35	sw.	6	4	10	17	7.5	17.6	6.1
Terra Haute	575	96	129	29.45	30.09	......	26.8	......	52	16	34	−15	24	19	33	24	21	82	3.14	......	9	7,040	s.	31	s.	16	5	11	15	6.9	12.8	0.5
Cincinnati	628	152	160	29.41	30.11	− .01	31.4	− 0.9	58	16	39	2	24	24	28	29	25	81	3.85	+ 0.5	13	5,209	se.	30	w.	6	6	10	15	6.8	13.9	3.5
Columbus	824	173	222	29.19	30.10	− .01	27.8	− 0.8	51	16	35	− 2	24	21	30	25	21	78	3.30	+ 0.4	16	8,042	se.	36	nw.	12	2	11	18	7.6	17.8	5.0
Dayton	899	181	216	29.09	30.08	......	27.6	− 1.3	54	16	35	− 6	24	20	30	25	22	82	3.88	+ 0.9	16	7,168	sw.	35	w.	2	9	12	10	5.8	22.0	7.1
Pittsburgh	842	353	410	29.16	30.10	− .01	30.6	− 0.1	55	17	38	4	29	23	26	28	24	77	4.66	+ 1.8	18	8,156	nw.	48	w.	2	5	6	20	7.7	14.6	3.0
Elkins	1,940	41	50	27.98	30.12	.00	31.8	+ 2.8	59	18	41	9	22	23	38	28	26	83	5.14	+ 1.8	18	3,213	w.	26	w.	18	3	7	21	8.1	13.2	T.
Parkersburg	638	77	84	29.44	30.11	− .01	31.9	+ 0.6	60	17	40	2	29	24	29	28	25	80	3.68	+ 0.5	15	4,347	se.	28	nw.	2	5	7	19	7.4	8.0	1.3
Lower Lake Region.							**24.6**	**+ 0.3**										**81**	**3.25**	**+ 0.6**										**7.4**		
Buffalo	767	247	280	29.21	30.08	+ .01	25.3	+ 0.6	50	6	31	0	30	20	30	23	21	83	5.02	+ 1.7	18	13,138	sw.	80	sw.	7	4	4	23	8.0	28.9	14.0
Canton	448	10	61	29.59	30.09	......	19.4	+ 3.1	51	7	28	−31	30	11	37	....	....	....	3.05	− 0.1	12	8,054	sw.	56	sw.	19	4	8	19	7.5	13.2	9.0
Oswego	335	76	91	29.71	30.09	+ .02	25.3	+ 1.4	47	7	31	− 4	30	19	26	24	21	85	3.65	+ 0.5	19	8,788	s.	36	ne.	13	3	3	25	8.2	22.2	14.0
Rochester	523	97	113	29.51	30.10	+ .03	25.6	+ 1.6	49	6	32	1	30	20	26	23	19	75	3.57	+ 0.4	17	7,011	sw.	38	sw.	7	7	4	20	7.3	22.9	10.0
Syracuse	597	97	113	29.44	30.11	+ .04	25.7	+ 2.7	51	7	32	− 1	30	19	29	23	20	78	4.69	+ 2.6	15	8,968	s.	46	s.	17	5	6	20	7.3	19.5	4.5
Erie	714	92	102	29.28	30.08	+ .01	26.6	+ 0.1	49	17	33	− 4	30	20	25	24	19	76	2.43	− 0.6	17	8,143	w.	36	s.	31	5	10	16	7.0	12.7	2.5
Cleveland	762	190	201	29.24	30.09	.00	26.0	− 0.2	50	17	33	0	30	20	31	23	20	77	2.52	+ 0.1	17	10,200	se.	48	n.	12	4	11	16	7.4	17.1	1.8
Sandusky	629	62	103	29.38	30.10	+ .01	25.0	− 1.3	51	17	32	− 4	24	18	29	23	20	82	2.41	+ 0.3	14	8,856	w.	44	sw.	7	7	6	18	6.8	15.3	7.0
Toledo	628	208	246	29.38	30.09	.00	24.4	− 1.2	49	17	32	− 4	24	17	24	22	19	83	2.43	+ 0.5	12	10,071	sw.	51	sw.	7	7	9	15	6.4	12.6	6.0
Fort Wayne	856	113	124	29.13	30.09	......	23.6	− 3.3	50	17	31	− 8	24	16	29	22	20	84	2.62	......	11	6,599	sw.	36	sw.	7	3	7	21	7.8	20.2	3.3
Detroit	730	218	245	29.26	30.08	.00	23.4	− 0.9	46	17	30	0	29	17	21	21	19	84	2.69	+ 0.7	13	8,620	w.	50	w.	7	4	10	17	7.3	13.1	4.6
Upper Lake Region.							**18.2**	**0.0**										**83**	**1.72**	**− 0.2**										**7.5**		
Alpena	609	13	92	29.35	30.05	+ .01	20.1	+ 1.4	39	17	26	− 9	28	14	26	18	16	83	1.46	− 0.7	12	9,000	nw.	39	nw.	2	2	10	19	7.7	8.1	2.4
Escanaba	612	54	60	29.33	30.03	− .02	15.2	+ 0.7	36	17	22	−23	28	8	36	15	12	86	2.98	+ 1.4	16	6,661	nw.	32	ne.	31	5	9	17	7.1	25.0	8.0
Grand Haven	632	54	92	29.34	30.06	− .01	23.5	− 1.0	45	16	29	0	28	18	20	22	18	80	1.89	− 0.9	10	8,927	w.	43	sw.	17	1	11	19	8.2	9.4	4.5
Grand Rapids	707	70	87	29.26	30.07	+ .01	23.3	− 0.5	43	16	29	− 1	28	18	20	21	18	80	1.57	− 1.2	13	5,149	se.	26	w.	7	0	10	21	8.3	6.0	3.0
Houghton	684	62	72	29.23	30.00	− .05	13.7	− 0.8	40	5	22	−31	28	6	36	....	....	....	3.22	+ 1.2	18	5,513	e.	35	n.	17	3	3	25	8.3	33.6	27.0
Lansing	878	11	62	29.09	30.06	......	20.4	− 1.6	42	17	28	−13	30	13	31	18	16	86	1.54	− 0.6	15	4,923	sw.	27	sw.	7	2	7	22	7.9	6.5	3.0
Ludington	637	60	66	29.31	30.03	......	22.6	......	44	16	28	− 6	28	17	20	21	19	86	1.69	......	15	9,163	se.	39	sw.	17	1	4	26	8.9	7.2	5.7
Marquette	734	77	111	29.19	30.03	− .01	16.3	+ 0.4	39	5	23	−17	28	9	24	14	11	81	2.41	+ 0.4	15	8,288	w.	47	s.	13	6	6	19	7.5	26.0	14.3
Port Huron	638	70	120	29.35	30.08	+ .02	20.8	− 1.0	44	17	28	−10	30	14	27	20	17	83	1.13	− 0.8	13	8,178	w.	38	nw.	2	4	10	17	7.2	9.8	8.9
Saginaw	641	48	82	29.35	30.08	......	20.1	......	41	17	27	−10	30	13	25	19	17	88	1.79	− 0.5	12	7,145	s.	37	sw.	7	4	7	20	7.6	6.9	4.8
Sault Ste. Marie	614	11	61	29.32	30.05	+ .02	14.6	+ 1.3	36	6	22	−18	28	7	33	13	11	84	1.37	− 0.8	12	6,107	se.	31	se.	13	6	4	21	7.6	12.3	15.8
Chicago	823	140	310	29.15	30.08	− .02	24.1	+ 0.4	47	16	30	− 8	28	18	23	22	18	76	1.99	0.0	10	9,015	sw.	38	w.	17	7	7	17	6.7	6.5	3.8
Green Bay	617	109	144	29.34	30.04	− .02	16.0	+ 1.4	39	16	23	−21	28	9	29	14	10	77	1.29	− 0.4	12	8,239	sw.	44	ne.	31	4	7	20	7.9	5.8	4.0
Milwaukee	681	119	133	29.28	30.04	− .04	19.8	0.0	43	16	27	−15	28	13	30	18	16	84	1.89	− 0.1	8	8,013	w.	39	se.	30	8	10	13	6.4	7.4	2.5
Duluth	1,133	11	47	28.74	30.03	− .06	9.2	− 1.2	37	5	17	−28	28	2	23	8	6	90	1.84	+ 0.9	11	10,001	sw.	58	nw.	17	9	8	14	5.9	17.4	5.4
North Dakota.							**6.3**	**+ 2.2**										**84**	**0.23**	**− 0.4**										**5.9**		
Moorhead	940	8	57	29.01	30.10	− .04	4.9	+ 2.2	34	4	14	−31	27	−5	36	3	1	86	0.35	− 0.4	8	6,599	n.	30	nw.	19	15	7	9	4.6	3.5	5.6
Bismarck	1,674	8	57	28.21	30.10	− .03	9.2	+ 2.5	40	12	19	−35	27	0	35	7	3	81	0.08	− 0.5	5	6,220	nw.	34	n.	19	7	9	15	6.4	1.7	5.2
Devils Lake	1,482	11	44	28.37	30.04	− .08	2.6	+ 2.3	32	4	12	−38	27	−6	30	2	0	89	0.11	− 0.5	4	6,831	nw.	35	n.	19	6	9	16	6.5	1.6	2.9
Williston	1,872	40	47	27.96	30.04	− .07	8.5	+ 2.0	36	18	18	−40	27	−1	34	7	3	81	0.38	− 0.2	4	4,014	sw.	32	nw.	12	9	5	17	6.2	3.4	2.5
Upper Mississippi Valley.							**20.8**	**− 0.7**										**83**	**2.08**	**+ 0.4**										**6.3**		
Minneapolis	918	10	208	28.99	30.02	......	12.6	......	41	5	20	−24	28	5	29	....	....	....	1.37	+ 0.7	10	9,051	s.	37	nw.	16	10	7	14	6.0	16.4	9.4
St. Paul	837	201	236	29.08	30.04	− .07	12.4	+ 0.8	40	5	20	−31	28	5	35	....	....	....	1.19	+ 0.3	10	9,146	nw.	39	n.	16	10	8	13	6.3	11.7	9.0
La Crosse	714	11	48	29.24	30.05	− .06	15.0	− 0.2	41	13	23	−28	28	7	31	....	....	....	1.63	+ 0.6	11	4,235	s.	18	w.	7	6	5	20	7.4	9.1	3.5
Madison	974	70	78	28.96	30.07	− .03	15.4	− 1.1	40	16	23	−23	28	8	33	14	12	85	2.05	+ 0.5	9	7,101	nw.	36	sw.	16	7	4	20	7.0	5.7	5.5
Charles City	1,015	10	49	28.92	30.05	− .09	13.4	+ 2.0	41	13	22	−29	28	5	31	13	11	88	1.60	+ 0.6	12	5,652	nw.	24	nw.	1	5	17	9	5.9	7.0	3.0
Davenport	606	71	79	29.38	30.08	− .04	19.0	− 1.8	49	16	27	−18	28	11	31	18	16	86	2.11	+ 0.5	11	5,732	nw.	34	sw.	16	9	9	13	5.8	6.9	1.5
Des Moines	861	84	97	29.09	30.04	− .10	20.8	+ 0.4	46	13	28	−18	28	13	29	19	15	78	1.96	+ 0.8	12	5,764	nw.	26	nw.	6	10	7	14	5.8	8.0	3.8
Dubuque	698	81	96	29.29	30.09	− .03	17.2	− 1.1	43	16	25	−22	28	9	30	16	13	85	2.01	+ 0.5	12	4,773	s.	27	s.	16	9	9	13	6.3	5.0	4.4
Keokuk	614	64	78	29.38	30.09	− .07	23.2	− 0.5	59	16	32	−16	28	15	34	21	19	84	0.90	− 0.8	11	4,842	nw.	27	nw.	6	11	10	10	5.2	6.2	T.
Cairo	356	87	93	29.69	30.09	− .07	34.1	− 0.7	57	15	41	10	24	27	24	31	26	75	4.85	+ 1.0	9	6,928	nw.	30	se.	16	6	11	14	6.5	4.5	....
Peoria	609	11	45	29.40	30.09	− .03	21.0	− 2.1	51	16	29	−18	28	13	32	20	18	88	1.89	− 0.3	10	5,448	s.	32	sw.	16	6	8	17	6.8	8.4	2.0
Springfield, Ill	644	10	91	29.37	30.08	− .05	24.7	− 1.6	53	16	32	−12	28	18	25	23	20	83	2.11	− 0.1	12	6,626	w.	27	sw.	16	9	5	17	6.6	11.2	2.2
Hannibal	534	74	109	29.48	30.08	− .05	24.8	− 1.9	60	16	33	−16	24	16	37	....	....	....	2.58	+ 0.4	12	6,199	sw.	40	sw.	16	8	9	14	6.2	16.4	2.5
St. Louis	567	265	303	29.45	30.08	− .06	29.6	− 1.4	59	16	37	− 4	28	22	27	27	22	77	2.83	+ 0.6	12	10,046	s.	43	sw.	16	9	7	15	6.2	11.6	T.
Missouri Valley.							**22.6**	**+ 1.6**										**82**	**1.52**	**+ 0.5**										**5.7**		
Columbia, Mo	781	11	84	29.18	30.05	− .08	27.2	0.0	61	15	36	−13	28	18	36	....	....	....	2.10	− 0.1	10	6,305	se.	36	sw.	16	9	8	14	5.9	5.1	....
Kansas City	963	161	181	28.98	30.05	− .10	28.6	+ 2.4	62	15	36	−10	28	21	31	25	21	75	2.53	+ 1.4	11	9,019	nw.	49	nw.	19	11	8	12	5.4	5.5	....
St. Joseph	967	11	49	28.98	30.06	......	25.6	......	58	15	33	−12	28	18	29	23	20	81	2.07	......	10	6,685	nw.	38	w.	16	10	10	11	5.6	7.2	T.
Springfield, Mo	1,324	98	104	28.61	30.05	− .09	32.2	+ 0.9	60	15	40	3	23	24	36	29	26	81	2.35	− 0.3	10	8,358	se.	38	nw.	19	15	2	14	5.1	2.8	....
Iola	984	11	50	28.96	30.05	− .09	30.4	+ 2.8	62	15	40	− 4	23	20	33	....	....	....	2.14	+ 1.2	8	5,605	nw.	28	nw.	19	10	8	13	5.6	3.1	....
Topeka	983	85	101	......	......	......	27.8	+ 2.2	57	15	36	− 9	28	20	31	....	....	....	1.23	+ 0.3	8	7,043	s.	37	n.	19	11	11	9	5.2	6.9	T.
Lincoln	1,189	11	84	28.73	30.05	− .10	21.9	+ 0.7	48	13	30	−22	28	14	38	20	18	85	1.78	+ 1.2	12	7,920	s.	46	nw.	19	12	9	10	5.3	23.0	7.8
Omaha	1,105	115	121	28.82	30.06	− .09	21.6	+ 1.1	47	13	28	−13	28	15	23	20	17	83	1.87	+ 1.2	11	7,011	nw.	39	nw.	16	8	9	14	5.9	12.4	3.0
Valentine	2,598	47	54	27.22	30.07	− .05	16.4	− 1.8	48	12	28	−22	23	5	45	15	13	87	0.57	0.0	9	7,020	nw.	36	nw.	19	10	5	16	5.9	6.0	4.5
Sioux City	1,135	94	164	28.78	30.05	− .10	18.6	+ 3.0	44	13	26	−16	28	11	28	17	15	85	1.06	+ 0.5	11	10,038	nw.	47	nw.	16	10	11	10	5.2	7.1	4.6
Huron	1,306	59	74	28.62	30.09	− .04	13.0	+ 3.5	43	13	22	−24	27	4	32	11	8	79	0.45	− 0.1	6	8,596	nw.	36	nw.	16	11	9	11	5.5	5.2	3.8
Pierre	1,572	70	75	28.36	30.11	− .05	15.6	+ 1.7	51	12	26	−20	27	6	36	13	10	82	0.73	+ 0.3	5	6,858	nw.	38	nw.	19	8	9	14	6.2	8.8	7.6
Yankton	1,233	49	57	28.68	30.06	− .10	18.0	+ 2.5	46	9	26	−18	27	10	33	....	....	....	1.42	+ 0.9	9	6,591	nw.	31	n.	19	5	11	15	6.9	9.7	9.0

TABLE I.—*Climatological data for United States Weather Bureau stations, January, 1915*—Continued.

Districts and stations.	Elevation of instruments: Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Pressure in inches: Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air, in degrees Fahrenheit: Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Precipitation, inches: Total.	Departure from normal.	Days with 0.01 or more.	Wind: Total movement, miles.	Prevailing direction.	Maximum velocity: Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
Northern Slope.							**19.7**	**+ 0.7**										**75**	**0.72**	**- 0.6**										**5.8**		
Havre	2,505	11	44	27.28	30.05	- .05	11.4	- 2.1	41	11	21	-29	27	2	41	11	9	89	0.67	0.0	8	5,093	w.	32	sw.	11	10	5	16	5.9	7.6	3.3
Helena	4,110	87	114	25.72	30.06	- .09	23.6	+ 3.6	46	19	32	-10	27	16	24	20	15	71	0.37	- 0.6	4	5,582	sw.	38	w.	19	6	12	13	6.2	5.9	2.9
Kalispell	2,962	11	34	26.91	30.10	- .02	20.2	+ 0.6	40	12	28	- 6	28	12	22	19	16	83	1.19	- 0.4	9	2,139	w.	20	sw.	12	2	12	17	7.6	11.9	9.3
Miles City	2,371	26	48	27.44	30.11	- .01	17.6	+ 3.1	47	4	28	-30	27	8	31	14	11	79	1.03	+ 0.4	8	3,241	n.	22	sw.	13	10	13	8	4.8	9.1	6.3
Rapid City	3,259	50	58	26.52	30.09	- .01	20.6	- 0.9	57	12	31	-20	22	10	42	18	12	72	1.15	+ 0.7	11	6,305	w.	38	nw.	19	10	8	13	5.7	10.6	5.1
Cheyenne	6,088	84	101	23.85	30.00	- .05	25.8	+ 0.2	55	3	36	- 9	22	15	38	20	13	64	0.08	- 0.3	5	12,371	w.	66	w.	12	8	13	10	5.7	1.0	0.1
Lander	5,372	60	68	24.53	30.09	- .03	19.3	+ 1.9	55	20	34	-18	22	5	42	14	7	63	0.44	0.0	2	3,140	sw.	44	w.	12	10	10	11	5.3	5.2	0.4
Sheridan	3,790	10	47	26.02	30.07	......	17.8	......	51	12	32	-22	27	4	45	16	11	75	2.08	......	12	3,996	nw.	48	sw.	12	12	6	13	5.7	22.1	12.0
Yellowstone Park	6,200	11	48	23.77	30.10	- .04	18.6	+ 1.0	43	29	28	- 8	27	10	33	16	12	74	0.47	- 1.8	12	5,387	s.	28	s.	12	9	5	17	6.3	5.0	2.5
North Platte	2,821	11	51	27.04	30.10	- .02	20.1	- 1.3	49	14	32	-22	23	9	46	16	13	82	0.51	0.0	6	5,336	w.	39	nw.	19	12	10	9	4.7	4.2	2.0
Middle Slope.							**30.8**	**+ 1.8**										**71**	**0.85**	**+ 0.1**										**4.8**		
Denver	5,291	129	172	24.60	29.99	- .06	29.3	+ 0.2	57	12	42	- 2	22	17	38	24	17	63	0.38	0.0	6	6,342	sw.	40	n.	5	15	9	7	4.3	4.6	1.0
Pueblo	4,685	80	86	25.18	29.99	- .06	29.6	+ 0.5	63	2	45	- 2	23	14	48	23	13	54	0.18	- 0.2	3	4,108	nw.	31	nw.	5	20	7	4	3.1	2.9	....
Concordia	1,398	42	50	28.53	30.06	- .08	26.5	+ 2.1	51	14	35	- 9	28	18	38	24	21	84	0.76	0.0	11	5,431	s.	32	nw.	19	10	5	16	5.9	5.4	0.2
Dodge	2,509	11	51	27.35	30.04	- .07	30.6	+ 3.3	61	30	42	- 1	22	19	36	25	19	69	1.08	+ 0.6	8	8,218	nw.	35	nw.	16	15	11	5	4.0	9.3	0.2
Wichita	1,358	139	158	28.54	30.02	- .11	32.0	+ 2.3	58	30	41	3	28	23	30	29	25	79	1.35	+ 0.6	8	9,545	s.	39	nw.	19	14	7	10	4.8	2.1	....
Oklahoma	1,214	10	47	28.73	30.05	- .06	37.1	+ 2.4	65	30	47	11	23	28	31	33	28	76	0.78	- 0.6	7	10,622	s.	46	sw.	30	11	11	9	5.2	0.5	0.3
Southern Slope.							**40.4**	**- 1.1**										**66**	**1.02**	**+ 0.3**										**4.3**		
Abilene	1,738	10	52	28.20	30.05	- .04	44.0	+ 1.4	74	30	55	18	23	32	39	36	29	65	0.67	- 0.2	7	7,939	s.	33	sw.	5	11	10	10	4.8	0.8	....
Amarillo	3,676	10	49	26.20	30.02	- .04	34.0	+ 0.1	64	14	46	9	22	22	50	29	25	77	0.72	+ 0.1	6	9,049	sw.	40	n.	31	22	7	2	3.3	5.9	0.8
Del Rio	944	64	71	29.06	30.07	+ .01	47.3	- 2.9	71	15	57	25	18	38	34	....	....	....	2.32	+ 1.5	7	6,637	se.	42	nw.	31	13	9	9	4.9	4.0	....
Roswell	3,566	75	85	26.33	30.03	- .01	36.2	- 3.0	62	21	50	7	23	22	43	29	19	55	0.38	- 0.2	3	5,846	nw.	44	w.	15	15	11	5	4.2	1.9	....
Southern Plateau.							**37.6**	**- 3.1**										**64**	**1.66**	**+ 0.9**										**4.0**		
El Paso	3,762	110	133	26.17	30.01	.00	41.2	- 2.9	72	29	52	13	24	30	33	34	24	56	1.01	+ 0.5	5	7,979	nw.	56	sw.	15	13	12	6	4.2	3.7	....
Santa Fe	7,013	57	62	23.13	30.08	+ .04	24.4	- 4.1	48	1	34	3	23	15	33	20	15	72	1.95	+ 1.4	8	5,147	n.	26	n.	27	13	13	5	4.4	15.3	1.0
Flagstaff	6,908	8	57	......	......	......	21.3	- 5.4	44	3	35	- 8	16	8	40	....	....	....	3.24	......	11	......	w.	34	w.	29	17	4	10	....	32.0	14.0
Phoenix	1,108	76	81	28.82	30.00	- .03	50.0	0.0	73	3	61	27	18	39	38	42	33	56	1.79	+ 0.6	4	3,646	w.	28	w.	15	16	4	11	4.4	....	....
Yuma	141	9	58	29.86	30.01	- .04	53.8	- 0.9	74	3	65	34	18	43	33	44	34	53	2.56	+ 2.1	3	4,457	n.	28	se.	29	20	7	4	2.5	....	....
Independence	3,910	11	42	25.96	30.01	- .06	35.2	- 5.3	56	19	46	18	11	24	32	31	28	82	0.98	+ 0.1	5	4,607	nw.	42	nw.	14	13	11	7	4.3	....	....
Middle Plateau.							**26.2**	**- 1.6**										**71**	**0.82**	**- 0.2**										**5.6**		
Reno	4,532	74	81	25.43	30.06	- .07	34.4	+ 1.9	56	1	45	9	23	24	33	29	23	68	0.55	- 1.4	8	3,609	w.	39	sw.	14	10	9	12	5.5	2.9	....
Tonopah	6,090	12	20	24.02	30.08	......	30.1	......	49	20	36	9	16	24	20	26	19	64	0.30	- 0.4	5	7,481	se.	40	nw.	14	12	13	6	4.7	4.0	T.
Winnemucca	4,344	18	56	25.60	30.09	- .07	29.3	+ 0.5	48	29	40	1	23	18	35	25	21	75	0.49	- 0.6	11	5,160	ne.	37	nw.	14	6	7	18	6.7	3.3	....
Modena	5,479	10	43	24.58	30.08	- .02	24.2	- 3.3	48	21	37	- 6	23	11	42	21	16	71	1.12	+ 0.4	7	6,143	w.	36	w.	25	10	8	13	5.6	12.7	3.0
Salt Lake City	4,360	147	189	25.62	30.10	- .05	28.2	- 0.6	44	27	36	7	23	21	26	25	18	66	0.72	- 0.6	8	3,892	se.	44	w.	12	9	11	11	5.4	5.2	....
Durango	6,546	10	....	23.57	30.12	+ .07	21.2	- 3.3	46	1	35	- 9	18	8	40	....	....	....	1.80	+ 0.5	7	......	n.	....	....	....	16	7	8	....	....	10.0
Grand Junction	4,602	82	96	25.40	30.10	+ .04	20.2	- 4.5	41	3	31	- 4	24	9	31	18	14	81	0.77	+ 0.3	7	3,259	w.	21	se.	6	11	8	12	5.5	7.1	....
Northern Plateau.							**27.3**	**- 1.5**										**78**	**0.80**	**- 0.8**										**7.4**		
Baker	3,471	48	53	26.46	30.16	.00	23.2	- 0.7	42	31	32	- 6	22	14	29	20	16	75	0.73	- 0.6	10	4,831	se.	24	sw.	14	9	9	13	5.7	7.4	0.5
Boise	2,739	78	86	27.22	30.18	- .01	27.6	- 1.7	49	31	35	6	24	20	21	25	21	76	1.06	- 0.8	10	2,981	nw.	29	nw.	13	5	6	20	7.4	3.7	....
Lewiston	757	40	48	29.27	30.10	- .06	32.6	- 1.9	49	4	38	17	26	27	22	....	....	....	0.55	- 1.0	6	2,694	e.	18	ne.	10	2	12	17	7.5	0.6	....
Pocatello	4,477	46	54	25.46	30.14	- .06	23.4	- 1.7	44	29	33	- 6	22	14	37	21	17	77	0.79	+ 0.1	11	5,360	se.	35	sw.	12	7	8	16	6.7	6.1	....
Spokane	1,929	101	110	27.98	30.10	- .02	26.2	- 0.5	45	8	32	8	25	20	21	25	22	81	0.91	- 1.4	10	3,243	sw.	21	sw.	4	0	7	24	8.7	8.0	7.2
Walla Walla	1,000	57	65	28.97	30.08	- .07	30.8	- 2.4	55	11	36	16	27	26	24	29	25	82	0.75	- 1.3	11	2,790	s.	26	se.	11	2	4	25	8.5	1.2	T.
North Pacific Coast Region.							**40.7**	**+ 1.3**										**83**	**5.39**	**- 1.3**										**7.2**		
North Head	211	11	56	29.71	29.94	- .11	43.8	+ 2.0	54	2	48	35	25	40	13	42	40	87	7.88	+ 1.2	18	12,850	e.	74	se.	10	8	2	21	7.2	....	....
Port Crescent	259	8	53	29.66	29.94	- .05	38.3	+ 2.3	49	31	44	24	26	32	19	....	....	....	2.78	- 2.8	15	4,610	se.	20	ne.	5	2	10	19	7.6	....	....
Seattle	125	215	250	29.85	29.98	- .07	40.6	+ 1.3	55	31	46	28	26	36	15	38	35	83	6.35	+ 1.8	16	4,836	se.	33	s.	31	5	4	22	7.4	....	....
Tacoma	213	113	120	29.75	29.98	- .06	39.0	+ 0.9	54	31	45	22	24	33	22	38	35	85	5.32	- 0.5	15	3,382	se.	25	ne.	21	4	11	16	7.3	....	....
Tatoosh Island	109	7	57	29.80	29.90	- .08	43.9	+ 2.7	55	29	47	38	12	41	12	41	38	81	6.57	- 5.6	15	16,861	e.	60	e.	29	9	6	16	6.4	....	....
Portland, Oreg.	153	68	106	29.82	29.99	- .09	39.2	+ 0.1	50	30	44	26	25	35	16	36	32	78	5.90	- 0.6	15	4,615	se.	26	e.	29	6	4	21	7.3	T.	....
Roseburg	510	9	57	29.42	29.98	- .12	40.3	- 0.5	57	30	46	26	23	35	24	38	36	85	2.93	- 2.8	16	2,066	s.	33	sw.	13	1	15	15	7.3	....	....
Middle Pacific Coast Region.							**47.5**	**+ 0.3**										**79**	**7.41**	**+ 2.7**										**6.3**		
Eureka	62	73	89	29.91	29.98	- .12	48.8	+ 1.9	66	2	56	32	16	42	25	46	42	81	9.75	+ 2.1	18	6,039	se.	38	se.	12	5	8	18	7.1	....	....
Mount Tamalpais	2,375	11	18	27.52	30.02	- .09	42.8	- 3.1	56	20	47	32	15	39	16	40	36	81	10.39	+ 4.4	19	14,279	nw.	60	nw.	8	7	3	21	7.2	....	....
Point Reyes Light	490	7	18	29.45	29.97	......	50.8	+ 1.4	61	19	55	43	11	47	16	....	....	....	7.25	......	19	16,406	s.	70	nw.	8	8	5	18	6.3	....	....
Red Bluff	332	50	56	29.68	30.04	- .08	44.5	- 0.9	62	21	51	30	23	38	27	41	37	80	8.95	+ 5.0	16	4,433	se.	21	n.	16	10	6	15	6.1	....	....
Sacramento	69	106	117	29.97	30.05	- .07	46.3	+ 0.7	59	22	52	33	23	40	22	43	40	79	3.76	+ 0.1	15	6,259	se.	27	se.	8	11	4	16	5.8	....	....
San Francisco	155	209	213	29.86	30.03	- .06	50.8	+ 1.3	63	22	56	42	17	46	17	46	42	76	6.74	+ 2.4	18	5,134	se.	33	sw.	11	10	5	16	5.3	....	....
San Jose	141	12	110	29.89	30.04	......	48.8	+ 0.5	66	28	57	30	18	40	31	....	....	....	4.85	+ 2.0	18	4,903	se.	31	se.	8	9	3	19	6.4	....	....
South Pacific Coast Region.							**52.5**	**+ 1.6**										**72**	**5.06**	**+ 2.3**										**5.2**	....	....
Fresno	327	89	98	29.70	30.07	- .03	47.4	+ 2.0	64	30	56	31	18	39	26	44	40	77	2.78	+ 1.2	14	3,803	e.	29	nw.	14	6	14	11	5.9	....	....
Los Angeles	338	159	191	29.65	30.02	- .06	55.9	+ 2.8	77	2	64	41	17	48	23	48	42	65	5.42	+ 2.6	12	5,043	ne.	36	ne.	28	11	12	8	4.8	....	....
San Diego	87	62	70	29.92	30.02	- .05	55.2	+ 1.2	69	1	63	38	17	48	22	49	44	71	4.91	+ 2.9	11	4,289	nw.	42	s.	28	16	6	9	4.3	....	....
San Luis Obispo	201	32	40	29.84	30.06	- .03	51.4	+ 0.4	72	2	61	30	18	42	40	46	42	73	7.11	+ 2.4	14	2,525	nw.	22	s.	29	11	4	16	5.8	....	....
West Indies.																																
San Juan	82	8	54	29.90	29.98	- .04	75.6	......	87	12	81	67	21	70	18	......	......	......	2.01	- 2.6	16	8,739	se.	46	ne.	23	14	14	3	4.1	....	....
Panama.																																
Balboa Heights	118	7	97	......	29.83	......	81.5	......	91	20	89	69	31	74	20	......	......	......	2.12	+ 1.1	6	7,024	n.	29	n.	13	12	15	4	....	....	....
Colon	25	5	71	......	29.84	......	81.5	......	87	6	86	74	28	78	12	......	......	......	3.41	- 0.5	16	9,494	n.	30	ne.	10	14	13	4	....	....	....

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during January, 1915, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex.	30			0.40														0.30			
Albany, N. Y.	7			0.56														.23			
Alpena, Mich.	6-7			0.87														(*)			
Amarillo, Tex.	30			0.12														.12			
Anniston, Ala.	16			0.71														.48			
Asheville, N. C.	18			0.45														.26			
Atlanta, Ga.	6	D. N. a. m.	2.00 p. m.	1.76	11.34 a. m.	12.18 p. m.	0.49	0.16	0.36	0.55	0.58	0.69	0.80	0.93	1.05	1.11					
Atlantic City, N. J.	18			1.37														.27			
Augusta, Ga.	6			1.46														.54			
Baker, Oreg.	14			0.19														(*)			
Baltimore, Md.	12			2.84														.33			
Bentonville, Ark.	30-31			0.80														.26			
Binghamton, N. Y.	7			0.45														.23			
Birmingham, Ala.	31-1[1]	2.00 p. m.	D. N. a. m.	2.73	9.50 p. m.	10.59 p. m.	.57	.22	.52	.74	.88	1.00	1.17	1.29	1.46	1.53	1.57	1.68	1.87		
Bismarck, N. Dak.	17			0.04														(*)			
Block Island, R. I.	7			0.68														.37			
Boise, Idaho.	8-9			0.46														(*)			
Boston, Mass.	7			0.68														.30			
Buffalo, N. Y.	6-7			1.29														(*)			
Burlington, Vt.	18-19			0.38														(*)			
Cairo, Ill.	30			1.32														.25			
Canton, N. Y.	6-7			1.02														(*)			
Charles City, Iowa.	31			0.26														(*)			
Charleston, S. C.	6	6.10 p. m.	8.50 p. m.	0.74	7.00 p. m.	7.27 p. m.	.05	.24	.35	.42	.45	.56	.61								
	18-19	8.30 a. m.	5.10 a. m.	1.59	12.30 p. m.	1.06 p. m.	.18	.07	.12	.15	.22	.31	.47	.56	.59						
Charlotte, N. C.	5-6	3.57 p. m.	8.22 p. m.	2.35	5.24 p. m.[2]	6.02 p. m.[2]	1.28	.12	.23	.32	.41	.49	.58	.90	.94						
Chattanooga, Tenn.	6			1.54														.38			
Cheyenne, Wyo.	21			0.03														(*)			
Chicago, Ill.	31			0.64														(*)			
Cincinnati, Ohio.	31			0.91														.19			
Cleveland, Ohio.	31			0.56														.07			
Columbia, Mo.	30			0.77														(*)			
Columbia, S. C.	17			1.17														.46			
Columbus, Ohio.	6			0.69														(*)			
Concord, N. H.	18-19			0.98														(*)			
Concordia, Kans.	21-22			0.23														(*)			
Corpus Christi, Tex.	3			0.45														.18			
Davenport, Iowa.	16			0.72														(*)			
Dayton, Ohio.	6			0.49														.16			
Del Rio, Tex.	3			1.36														.18			
Denver, Colo.	5			0.13														(*)			
Des Moines, Iowa.	31			0.47														(*)			
Detroit, Mich.	31			1.08														(*)			
Devils Lake, N. Dak.	5			0.06														(*)			
Dodge City, Kans.	16			0.62														(*)			
Dubuque, Iowa.	16			0.61														(*)			
Duluth, Minn.	15-16			1.16														(*)			
Durango, Colo.	29-30			1.14														(*)			
Eastport, Me.	7			0.72														.33			
Elkins, W. Va.	6			1.00														.22			
El Paso, Tex.	30			0.57														.19			
Erie, Pa.	22-23			0.48														(*)			
Escanaba, Mich.	16-17			1.10														(*)			
Eureka, Cal.	5			1.09														.34			
Evansville, Ind.	31			2.08														.32			
Flagstaff, Ariz.	29			2.05														(*)			
Fort Smith, Ark.	30-31			1.02														.80			
Fort Wayne, Ind.	16			0.26														.15			
Fort Worth, Tex.	30			0.21														.17			
Fresno, Cal.	8			0.57														.24			
Galveston, Tex.	10	8.55 a. m.	12.55 p. m.	0.82	12.03 p. m.	12.18 p. m.	.19	.09	.29	.53											
	16	7.45 a. m.	11.45 a. m.	0.94	10.05 a. m.	10.41 a. m.	.10	.07	.13	.20	.35	.63	.68	.74	.76						
Grand Haven, Mich.	30-31			0.79														(*)			
Grand Junction, Colo.	4-5			0.28														(*)			
Grand Rapids, Mich.	6			0.60														.14			
Green Bay, Wis.	16-17			0.45														(*)			
Hannibal, Mo.	21-22			0.80														(*)			
Harrisburg, Pa.	6			0.98														.23			
Hartford, Conn.	17-18			1.67														(*)			
Hatteras, N. C.	24			2.76														.58			
Havre, Mont.	4, 14-15			0.21														(*)			
Helena, Mont.	26			0.24														(*)			
Houghton, Mich.	15-17			0.94														(*)			
Houston, Tex.	10	8.28 a. m.	12.10 p. m.	0.56	10.22 a. m.	10.28 a. m.	.08	.31	.36												
Huron, S. Dak.	30-31			0.34														(*)			
Independence, Cal.	28			0.46														.08			
Indianapolis, Ind.	22			0.91														(*)			
Iola, Kans.	16			0.78														.26			
Jacksonville, Fla.	5-6			2.16														(*)			
Kalispell, Mont.	25-26			0.59														(*)			
Kansas City, Mo.	16			0.56														0.29			
Keokuk, Iowa.	30			0.25														(*)			
Key West, Fla.	25	11.39 a. m.	1.25 p. m.	1.04	11.46 a. m.	12.27 p. m.	0.01	0.23	0.51	0.67	0.79	0.81	0.83	0.86	0.77	1.00					
Knoxville, Tenn.	5-6			1.06														(*)			
La Crosse, Wis.	31			0.46														(*)			
Lander, Wyo.	21			0.32														(*)			
Lansing, Mich.	31			0.42														(*)			
Lewiston, Idaho.	14			0.30														(*)			
Lexington, Ky.	31			0.98														0.18			
Lincoln, Nebr.	16			0.58														(*)			
Little Rock, Ark.	31			1.18														.38			
Los Angeles, Cal.	29			1.63														.53			
Louisville, Ky.	31			1.59														.42			
Ludington, Mich.	31			0.65														(*)			
Lynchburg, Va.	6			1.55														.43			
Macon, Ga.	18			2.13														.77			
Madison, Wis.	16			0.75														.26			
Marquette, Mich.	6-7			0.71														(*)			

* Self-register not marking.

[1] February.

[2] Jan. 6.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during January, 1915, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive rate began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Memphis, Tenn.	31			1.70														.43			
Meridian, Miss.	31	11.10 a.m.	D. N. p.m.	2.49	5.16 p.m.	5.46 p.m.	.88	.08	.41	.65	.78	.86	.92								
Miami, Fla.	4			0.54														.39			
Milwaukee, Wis.	30-31			0.65														(*)			
Minneapolis, Minn.	15-16			0.69														(*)			
Mobile, Ala.	6	D. N. a.m.	8.15 a.m.	1.04	5.57 a.m.	6.34 a.m.	.08	.12	.26	.45	.61	.70	.75	.81	.85						
Mobile, Ala.	16-17	3.45 p.m.	9.00 a.m.	2.50	10.14 p.m.	10.48 p.m.	.63	.14	.28	.45	.48	.55	.59	.67							
Mobile, Ala.	23	7.45 a.m.	D. N. p.m.	1.90	10.31 a.m.	11.13 a.m.	.26	.14	.28	.39	.43	.48	.52	.60	.66	.71					
Modena, Utah	28-29			0.65														(*)			
Montgomery, Ala.	6	7.15 a.m.	11.25 a.m.	1.99	8.48 a.m.	9.13 a.m.	.73	.15	.21	.33	.45	.55									
Moorhead, Minn.	5-6			0.15														(*)			
Mount Tamalpais, Cal.	8			1.12														.59			
Nantucket, Mass.	25			0.68														.37			
Nashville, Tenn.	31			2.02														.43			
New Haven, Conn.	12			1.79														.24			
New Orleans, La.	16-17	5.00 p.m.	D. N. a.m.	1.84	6.51 p.m.	7.11 p.m.	.11	.25	.36	.42	.53										
New Orleans, La.	23	D. N. a.m.	6.35 p.m.	3.05	7.18 a.m.	7.38 a.m.	.06	.25	.41	.61	.70										
New York, N. Y.	13			0.92														.27			
Norfolk, Va.	24			1.72														.26			
Northfield, Vt.	18-19			0.58														(*)			
North Head, Wash.	8			0.65														.21			
North Platte, Nebr.	21			0.25														(*)			
Oklahoma, Okla.	30			0.30														.15			
Omaha, Nebr.	16			0.55														(*)			
Oswego, N. Y.	6-7			0.92														(*)			
Palestine, Tex.	31	1.30 a.m.	7.40 a.m.	1.02	1.43 a.m.	2.09 a.m.	.01	.13	.30	.55	.71	.78	.82								
Parkersburg, W. Va.	6			0.55														.13			
Pensacola, Fla.	31-1[1]	10.10 p.m.	4.35 a.m.	1.48	10.59 p.m.	11.23 p.m.	.01	.23	.42	.57	.66	.71									
Peoria, Ill.	16			0.35														.16			
Philadelphia, Pa.	12			2.19														.53			
Phoenix, Ariz.	29			1.45														.47			
Pierre, S. Dak.	30-31			0.62														(*)			
Pittsburgh, Pa.	18			0.71														.19			
Pocatello, Idaho	29-30			0.43														(*)			
Point Reyes Light, Cal.	8			0.76														.33			
Port Huron, Mich.	31			0.30														(*)			
Portland, Me.	25			1.82														.27			
Portland, Oreg.	17-18			1.87														(*)			
Providence, R. I.	6	8.18 p.m.	10.54 p.m.	1.07	8.50 p.m.	9.04 p.m.	.13	.24	.59	.65											
Pueblo, Colo.	15			0.12														(*)			
Raleigh, N. C.	6	8.18 p.m.	10.54 p.m.	1.07	8.50 p.m.	9.04 p.m.	.13	.24	.59	.65											
Rapid City, S. Dak.	20-21			0.44														(*)			
Reading, Pa.	13			1.21														.43			
Red Bluff, Cal.	8			1.26														.40			
Reno, Nev.	26-27			0.24														(*)			
Richmond, Va.	6			0.61														.33			
Rochester, N. Y.	25			1.05														(*)			
Roseburg, Oreg.	13			0.62														.23			
Roswell, N. Mex.	30			0.20														(*)			
Sacramento, Cal.	3			0.44														.33			
Saginaw, Mich.	31			0.71														(*)			
St. Joseph, Mo.	31			0.39														(*)			
St. Louis, Mo.	29-30			1.39														(*)			
St. Paul, Minn.	15-16			0.44														(*)			
Salt Lake City, Utah	4			0.32														(*)			
San Antonio, Tex.	31			0.10														.09			
San Diego, Cal.	21			1.67														.46			
Sand Key, Fla.	4-5	4.20 p.m.	9.05 a.m.	4.39	10.15 p.m.	11.06 p.m.	.76	.06	.13	.21	.27	.35	.39	.47	.62	.82	.86	.94			
Sand Key, Fla.	25	11.21 a.m.	1.19 p.m.	0.73	11.53 a.m.	12.31 p.m.	.01	.13	.23	.34	.43	.58	.63								
Sandusky, Ohio	31			0.74														(*)			
San Francisco, Cal.	8			0.95														.54			
San Jose, Cal.	3			0.52														.40			
San Luis Obispo, Cal.	29			1.91														.33			
Santa Fe, N. Mex.	15-16			0.93														(*)			
Sault Ste. Marie, Mich.	6-7			0.57														(*)			
Savannah, Ga.	18			1.43														.36			
Scranton, Pa.	22-23			1.32														(*)			
Seattle, Wash.	3			1.79														.17			
Sheridan, Wyo.	20-21			1.11														(*)			
Shreveport, La.	31	3.40 a.m.	10.40 a.m.	1.54	3.43 a.m.	4.01 a.m.	.01	.22	.35	.40	.45										
Sioux City, Iowa	31			0.52														(*)			
Spokane, Wash.	13			0.38														(*)			
Springfield, Ill.	30			0.80														(*)			
Springfield, Mo.	31			0.60														.27			
Syracuse, N. Y.	12			1.70														(*)			
Tacoma, Wash.	13			0.49														.13			
Tampa, Fla.	11			1.57														.49			
Tatoosh Island, Wash.	11			0.95														.47			
Taylor, Tex.	30-31	D. N. p.m.	D. N. a.m.	0.77	11.59 p.m.	12.25 a.m.	.01	.19	.35	.46	.52	.60	.61								
Terre Haute, Ind.	22			0.83														(*)			
Thomasville, Ga.	17-18	4.45 p.m.	3.10 p.m.	4.11	5.26 a.m.	5.44 a.m.	1.18	.11	.22	.44	.55										
Thomasville, Ga.					7.37 a.m.	8.53 a.m.	1.91	.08	.10	.23	.30	.34	.37	.48	.54	.57	.63	.82	1.23		
Toledo, Ohio	31			0.77														(*)			
Tonopah, Nev.	29			0.14														(*)			
Topeka, Kans.	16			0.56														(*)			
Valentine, Nebr.	20-21			0.18														(*)			
Vicksburg, Miss.	31	7.44 a.m.	5.05 p.m.	1.44	12.07 p.m.	12.32 p.m.	.44	.11	.35	.48	.63	.74									
Walla Walla, Wash.	13-14			0.30														(*)			
Washington, D. C.	6-7			1.02														.30			
Wichita, Kans.	10			0.59														(*)			
Williston, N. Dak.	5			0.22														(*)			
Wilmington, N. C.	18	4.05 p.m.	9.50 a.m.	2.38	8.16 a.m.	9.34 a.m.	1.16	.06	.16	.25	.29	.34	.38	.52	.63	.72	.85	.99	1.21		
Wilmington, N. C.		11.40 a.m.	7.25 p.m.	1.34	12.55 p.m.	1.41 p.m.	.03	.07	.24	.35	.46	.54	.63	.76	.85	.95	.97				
Winnemucca, Nev.	27-28			0.26														(*)			
Wytheville, Va.	6			0.83														.20			
Yankton, S. Dak.	31			1.02														(*)			
Yellowstone Park, Wyo.	13-14			0.19														(*)			

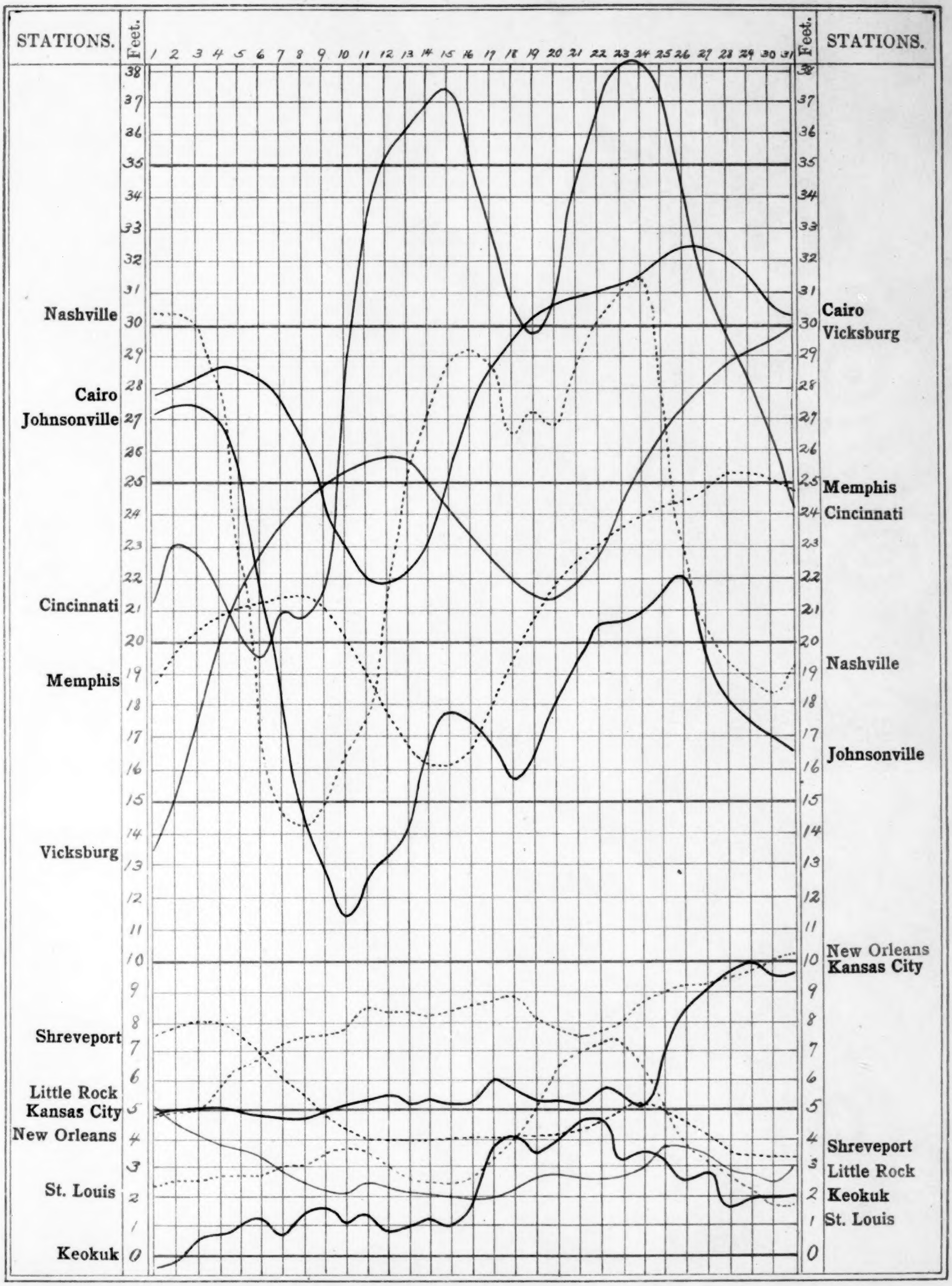
* Self-register not mark in

[1] February.

TABLE III.—*Data furnished by the Canadian Meteorological Service, January, 1915.*

Stations.	Pressure.			Temperature.						Precipitation.		
	Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Inches.	*Inches.*	*Inches.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*Inches.*	*Inches.*	*Inches.*
St. Johns, N. F	29.77	29.91	+0.05	25.9	+ 2.1	31.4	20.4	50	2	3.12	−2.79	7.0
Sydney, C. B. I	30.03	30.07	+ .14	26.1	+ 5.6	32.2	20.0	52	− 6	1.90	−3.20	7.0
Halifax, N. S	30.00	30.11	+ .14	24.8	+ 3.0	34.6	14.9	51	− 9	8.38	+2.61	21.9
Yarmouth, N. S	30.03	30.10	+ .10	28.9	+ 2.6	35.2	22.6	50	6	5.70	+0.29	10.2
Charlottetown, P. E. I	30.04	30.08	+ .12	22.4	+ 5.4	29.5	15.3	46	−13	5.05	+1.09	22.4
Chatham, N. B	30.09	30.12	+ .15	17.0	+ 7.2	26.7	7.3	52	−24	2.99	−0.60	12.1
Father Point, Que	30.04	30.07	+ .09	15.1	+ 7.1	21.9	8.3	48	−20	1.58	−1.27	12.2
Quebec, Que	29.75	30.09	+ .07	14.6	+ 5.5	21.8	7.4	44	−22	3.03	−0.98	20.0
Montreal, Que	29.87	30.10	+ .06	17.5	+ 5.8	24.2	10.8	45	−13	3.65	−0.08	15.6
Stonecliffe, Ont	29.46	30.10	+ .08	11.7	+ 5.3	21.9	1.5	40	−35	1.76	−1.56	13.0
Ottawa, Ont	29.83	30.18	+ .15	15.3	+ 5.7	23.3	7.3	42	−24	3.18	+0.19	14.5
Kingston, Ont	29.78	30.12	+ .07	22.0	+ 4.9	29.5	14.4	44	−24	1.91	−1.54	8.0
Toronto, Ont	29.65	30.05	0.00	23.6	+ 2.2	30.7	16.5	47	− 1	3.53	+0.61	27.2
White River, Ont	28.57	29.95	− .06	3.6	+ 4.0	17.6	−10.5	36	−56	1.40	−0.29	14.0
Port Stanley, Ont	29.40	30.07	0.00	20.0	− 2.2	28.3	11.6	40	−25	3.07	+0.08	20.5
Southampton, Ont	29.32	......	......	20.8	+ 0.4	27.5	14.2	40	0	3.30	−0.75	29.0
Parry Sound, Ont	29.32	30.05	+ .04	17.0	+ 3.2	25.6	8.5	40	−22	1.86	−2.22	12.0
Port Arthur, Ont	29.27	30.01	− .06	9.2	+ 6.1	18.3	0.1	39	−34	0.69	−0.13	6.9
Winnipeg, Man	29.18	30.08	− .03	0.4	+ 7.2	7.9	− 7.0	30	−37	0.38	−0.50	3.8
Minnedosa, Man	28.10	30.04	− .06	0.9	+ 8.1	10.1	− 8.3	30	−41	0.30	−0.50	3.0
Qu'Appelle, Sask	27.60	29.97	− .11	5.0	+ 8.8	13.3	− 3.3	32	−42	0.50	0.00	5.0
Medicine Hat, Alberta	27.60	29.98	− .09	15.0	+ 9.5	24.2	5.8	42	−27	0.38	−0.19	3.8
Swift Current, Sask	27.28	29.99	− .10	9.3	+ 6.2	18.7	− 0.1	44	−35	0.48	−0.16	4.8
Calgary, Alberta	26.27	29.92	− .11	19.8	+11.4	30.7	8.9	47	−24	0.40	−0.13	4.0
Banff, Alberta	25.23	30.02	+ .02	16.0	+ 3.9	25.5	6.5	37	−20	1.05	−0.14	10.5
Edmonton, Alberta	27.54	29.94	− .09	10.8	+ 9.0	20.5	1.0	42	−24	1.04	+0.36	7.1
Prince Albert, Sask	28.31	29.96	− .13	− 0.6	− 7.8	5.0	− 6.3	30	−42	0.11	−0.86	1.1
Battleford, Sask	28.16	30.00	− .08	4.8	+10.7	13.8	− 4.2	35	−38	0.00	−0.40	0.0
Kamloops, B. C	28.80	30.07	+ .11	23.3	+ 0.3	29.0	17.5	40	2	0.93	+0.11	9.3
Victoria, B. C	29.69	29.95	− .02	40.5	+ 2.0	44.3	36.7	49	31	1.55	−3.84	0.0
Barkerville, B. C	25.47	29.86	− .03	19.6	+ 1.8	26.5	12.8	36	− 2	0.77	−1.83	7.7
Hamilton, Bermuda	30.02	30.19	+ .06	63.4	+ 1.4	69.0	57.9	74	53	2.80	−2.14	0.0

Chart I. Hydrographs of Several Principal Rivers, January, 1915.



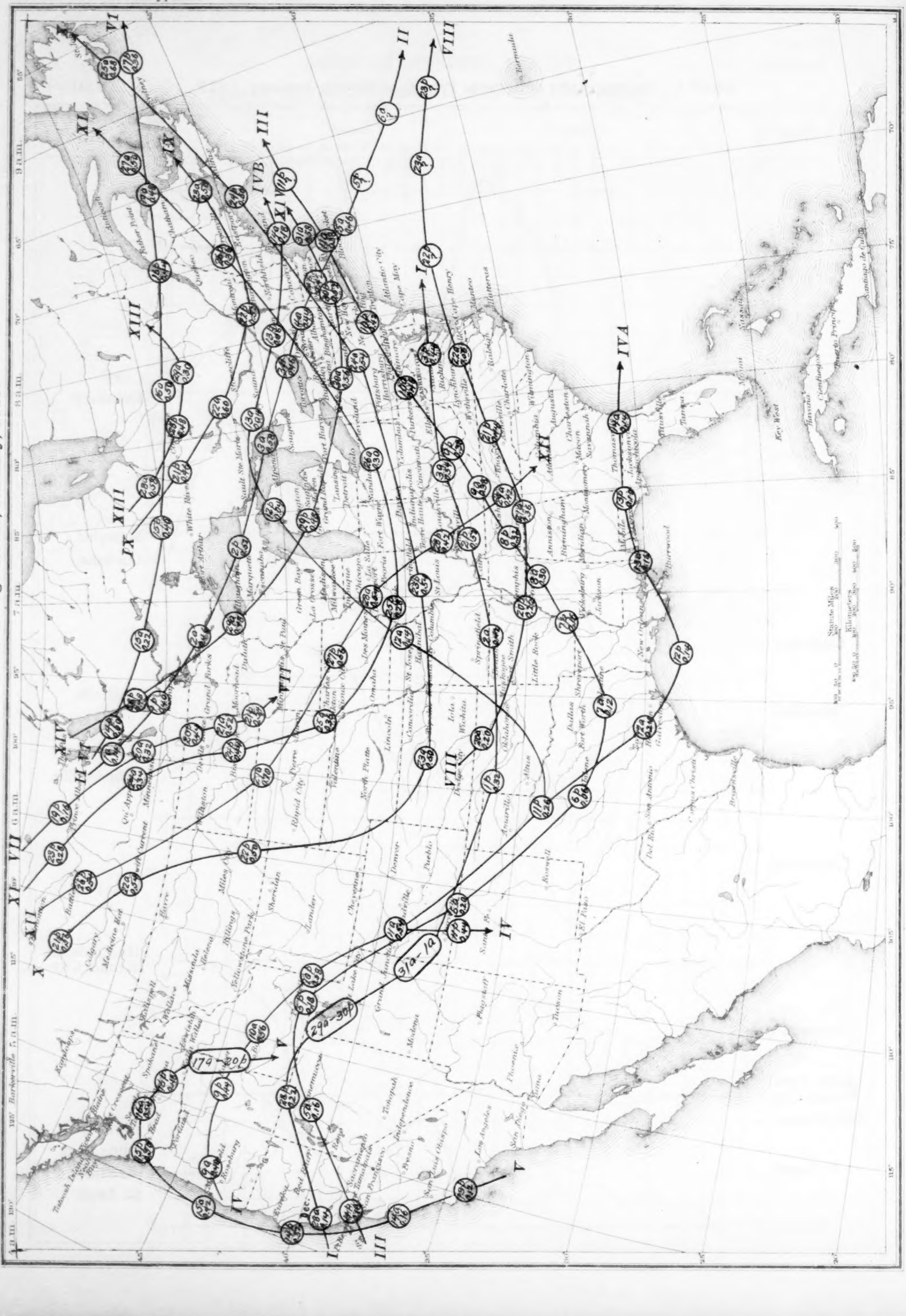


Chart II. Tracks of Centers of High Areas, January, 1915.

Chart III. Tracks of Centers of Low Areas, January, 1915.

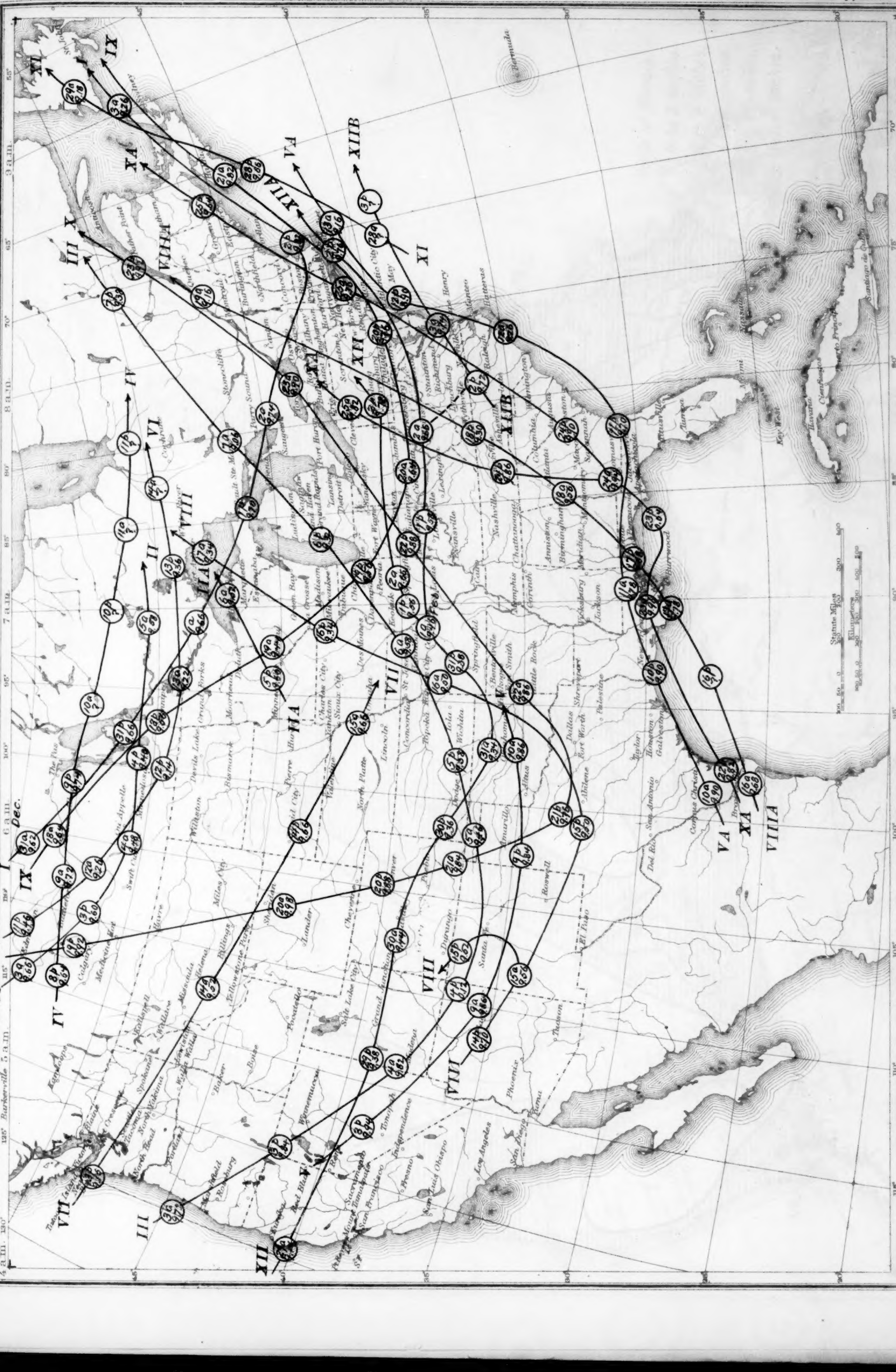


Chart IV. Departure of the Mean Temperature from the Normal, January, 1915.

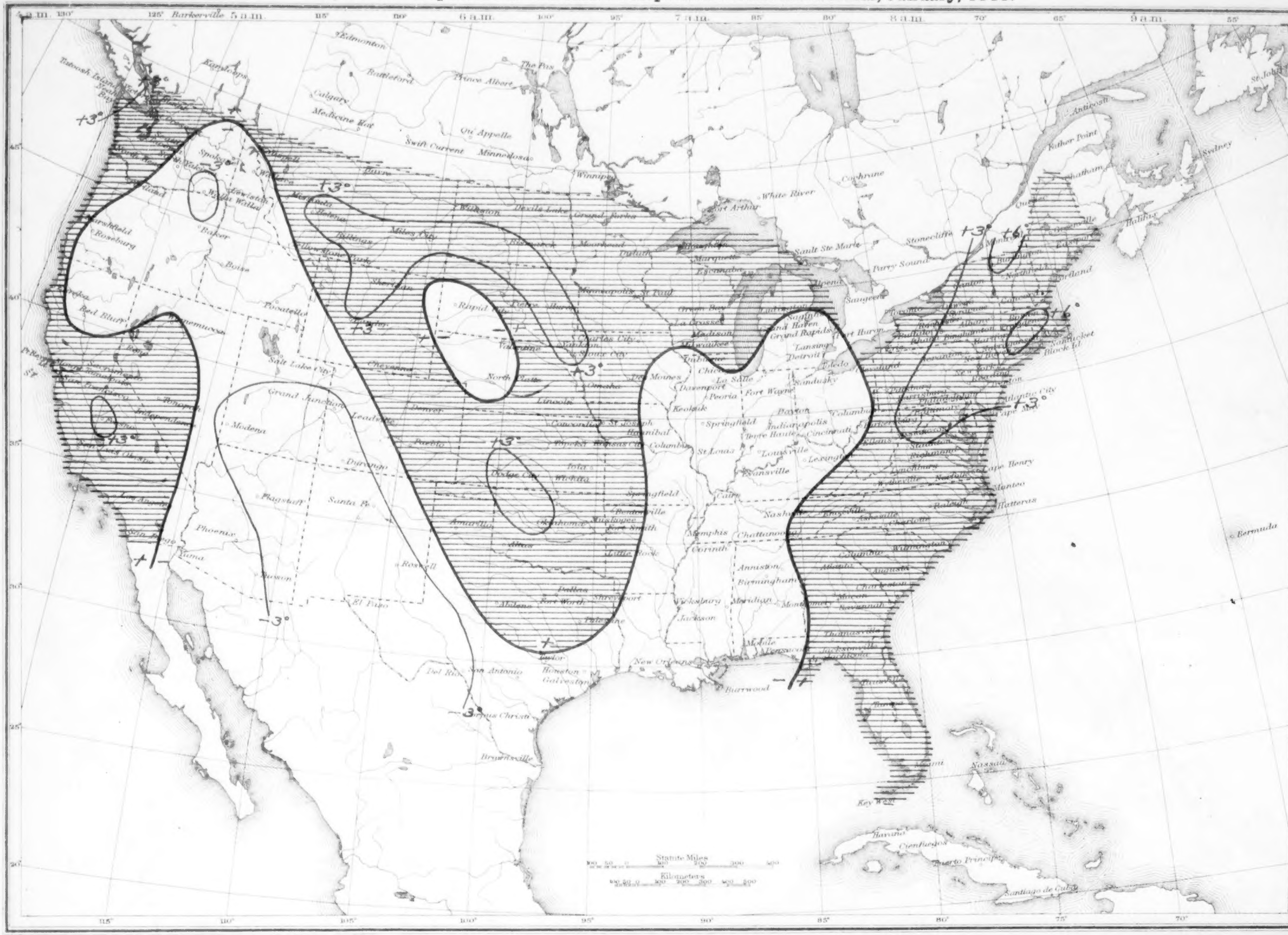


Chart V. Total Precipitation, January, 1915.

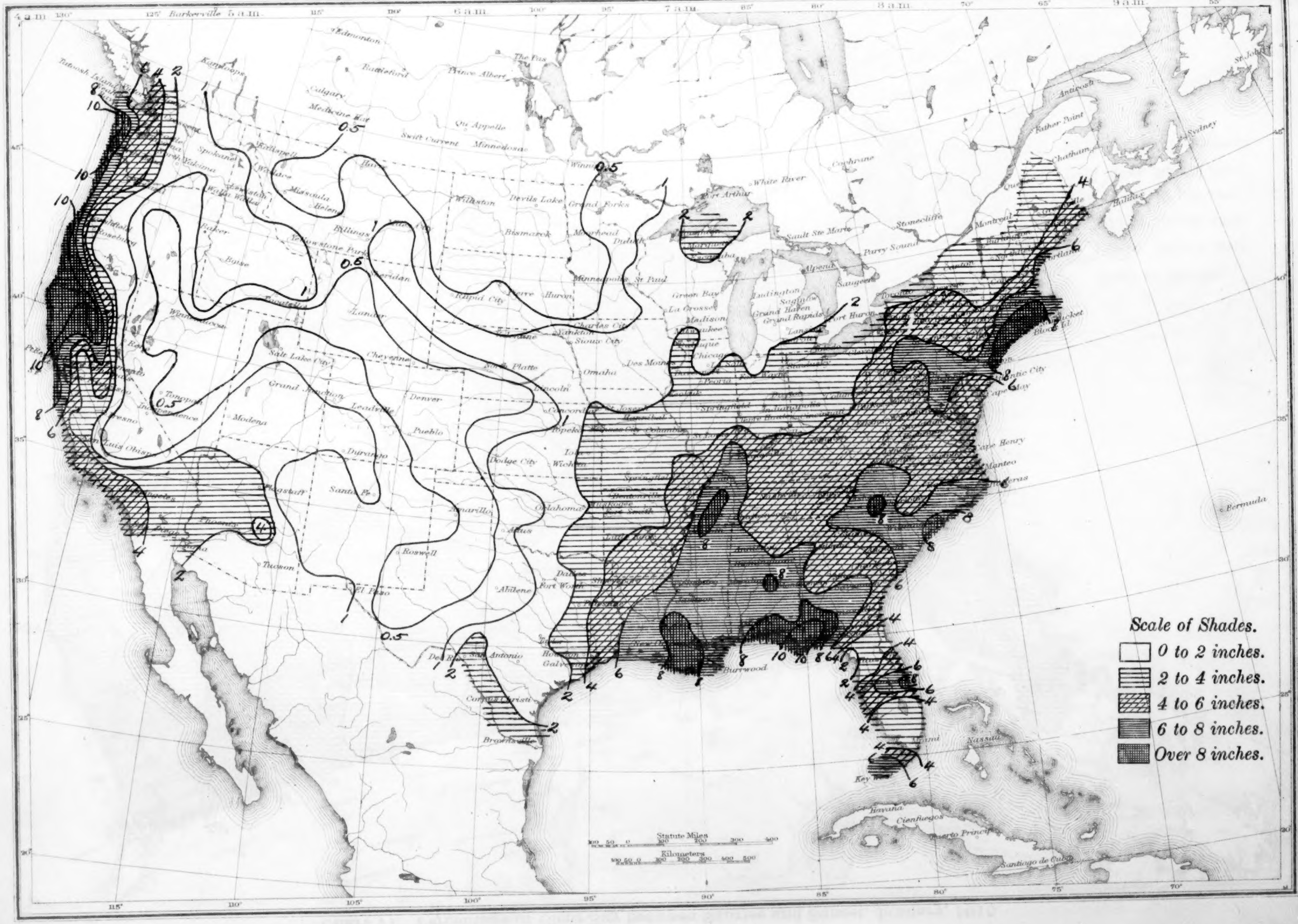


Chart VI. Percentage of Clear Sky between Sunrise and Sunset, January, 1915.

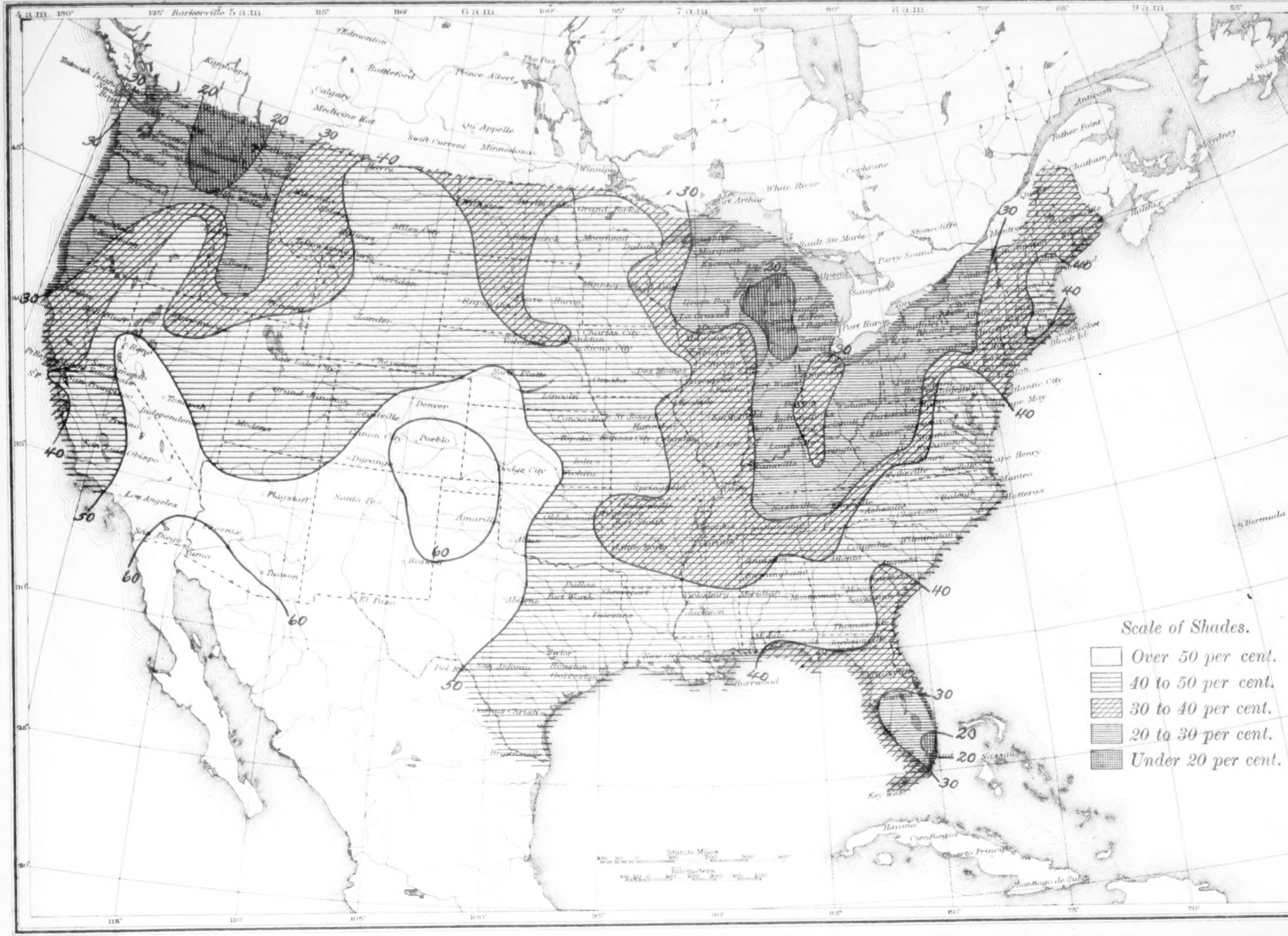


Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, January, 1915.

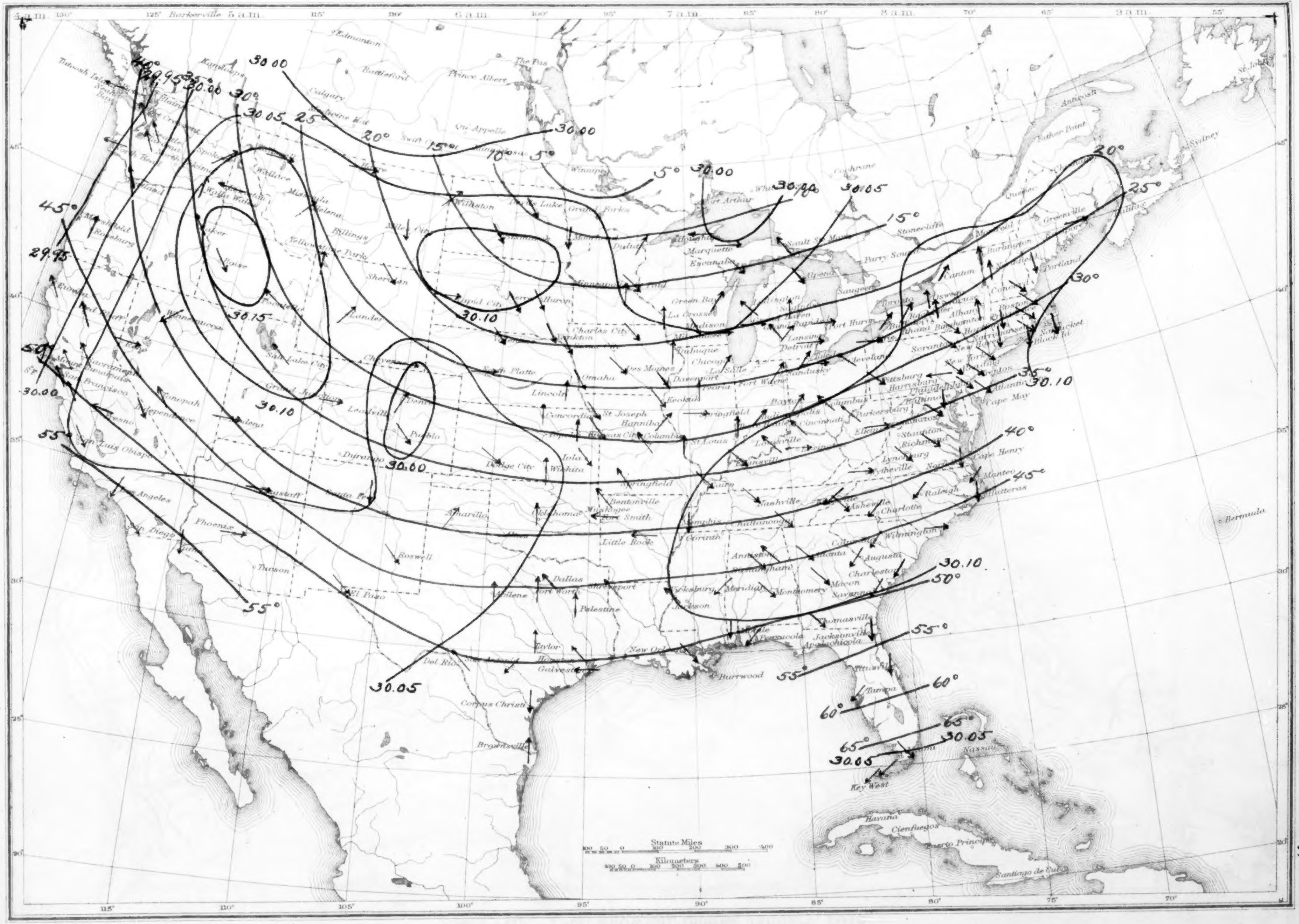
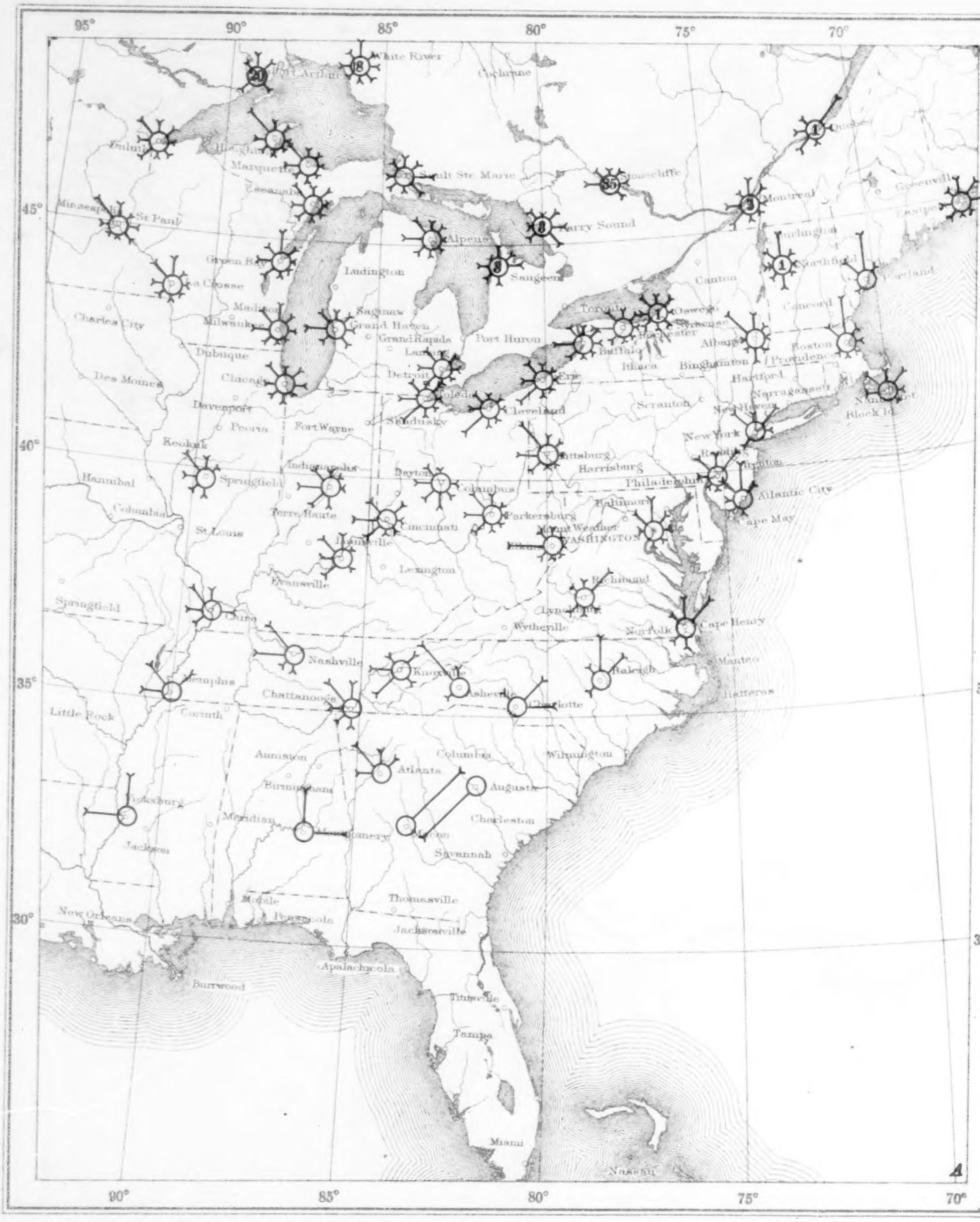


Chart VIII. Total Snowfall, inches, January, 1915.

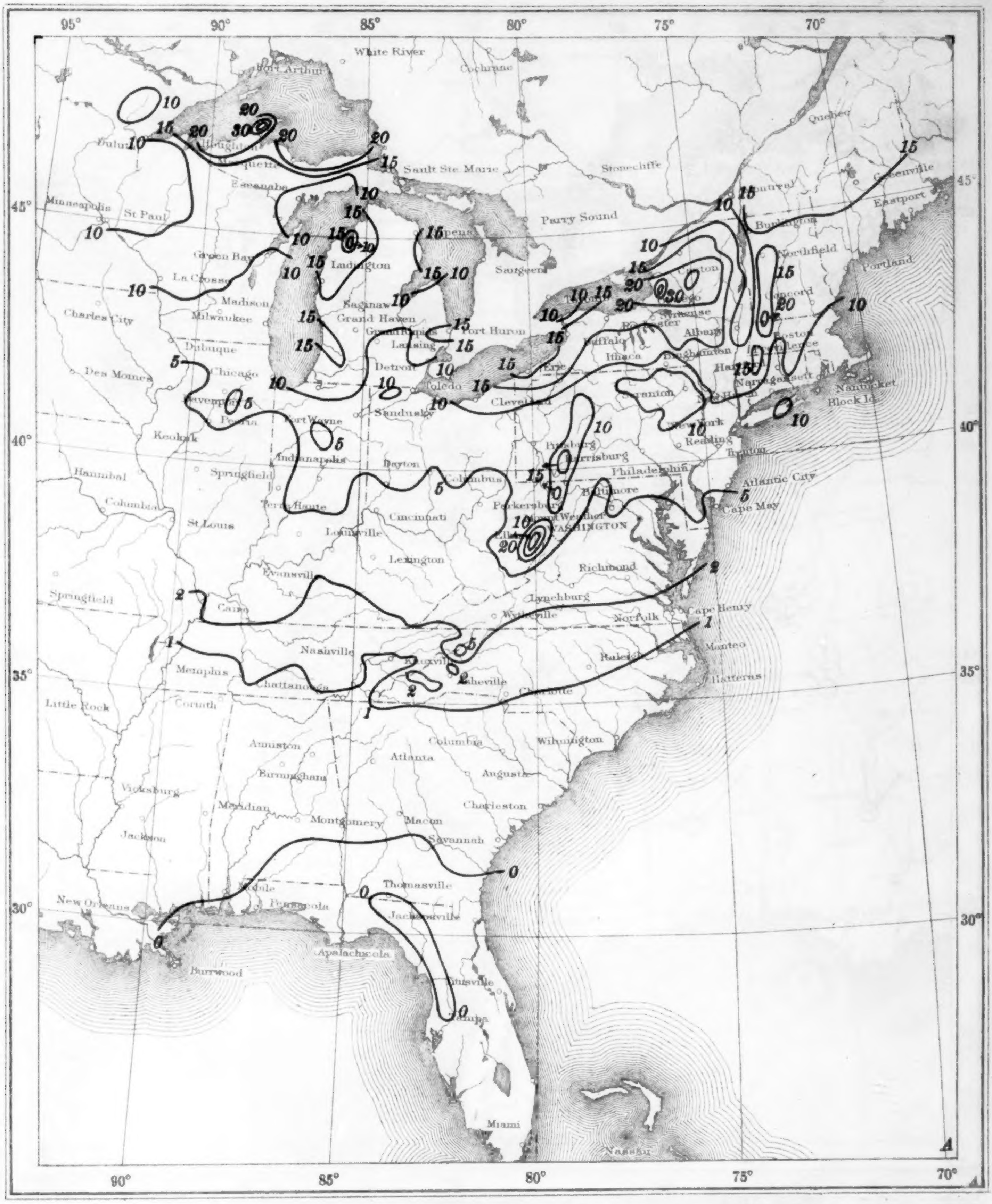
C. F. B. 1.—Average September snowfall (inches) over the eastern United States.

C. F. B. 2.—Average October snowfall (inches) over the eastern United States.

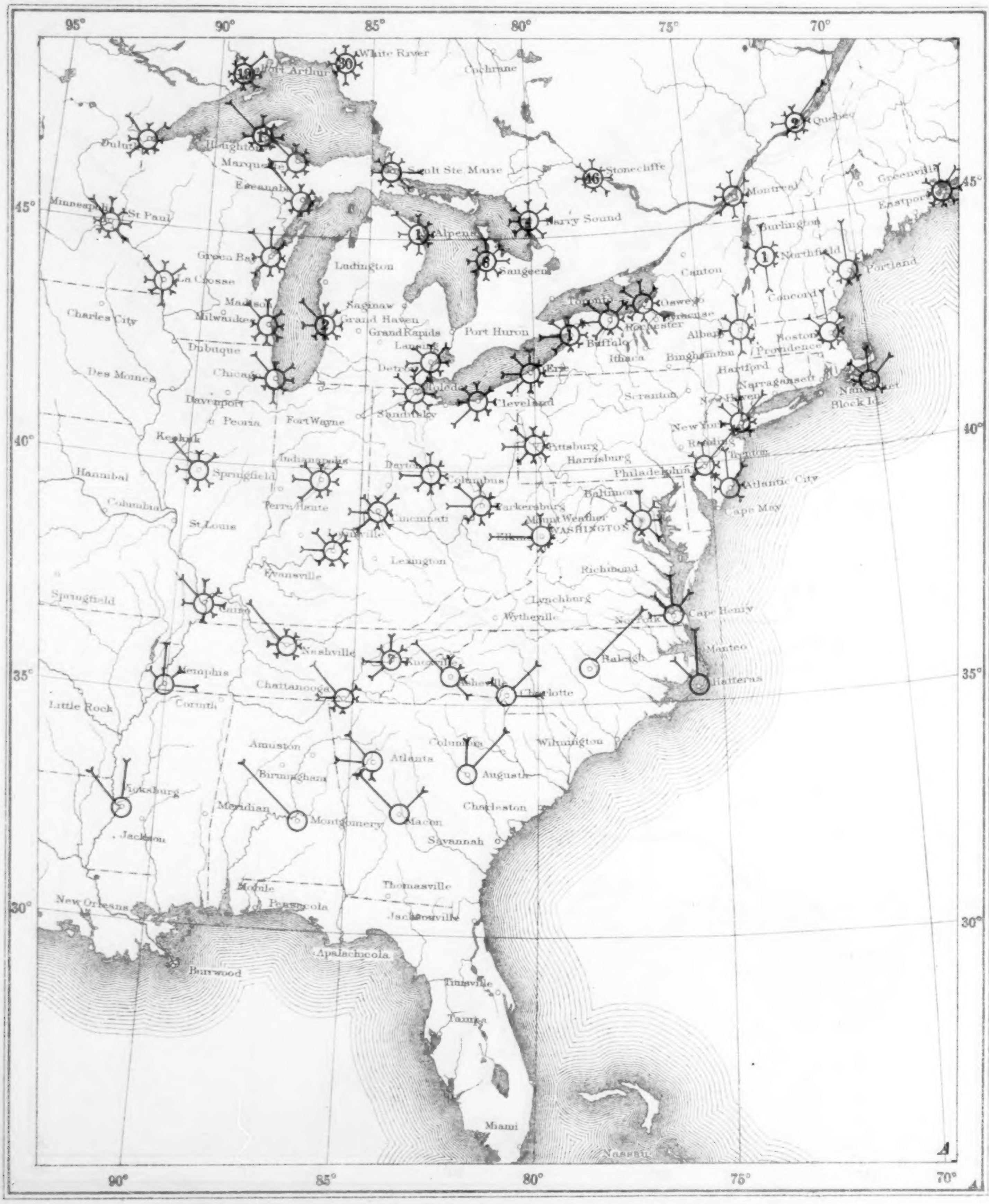
C. F. B. 3.—Average November snowfall (inches) over the eastern United States.



C. F. B. 4.—Snow-bearing winds in December over the eastern United States.

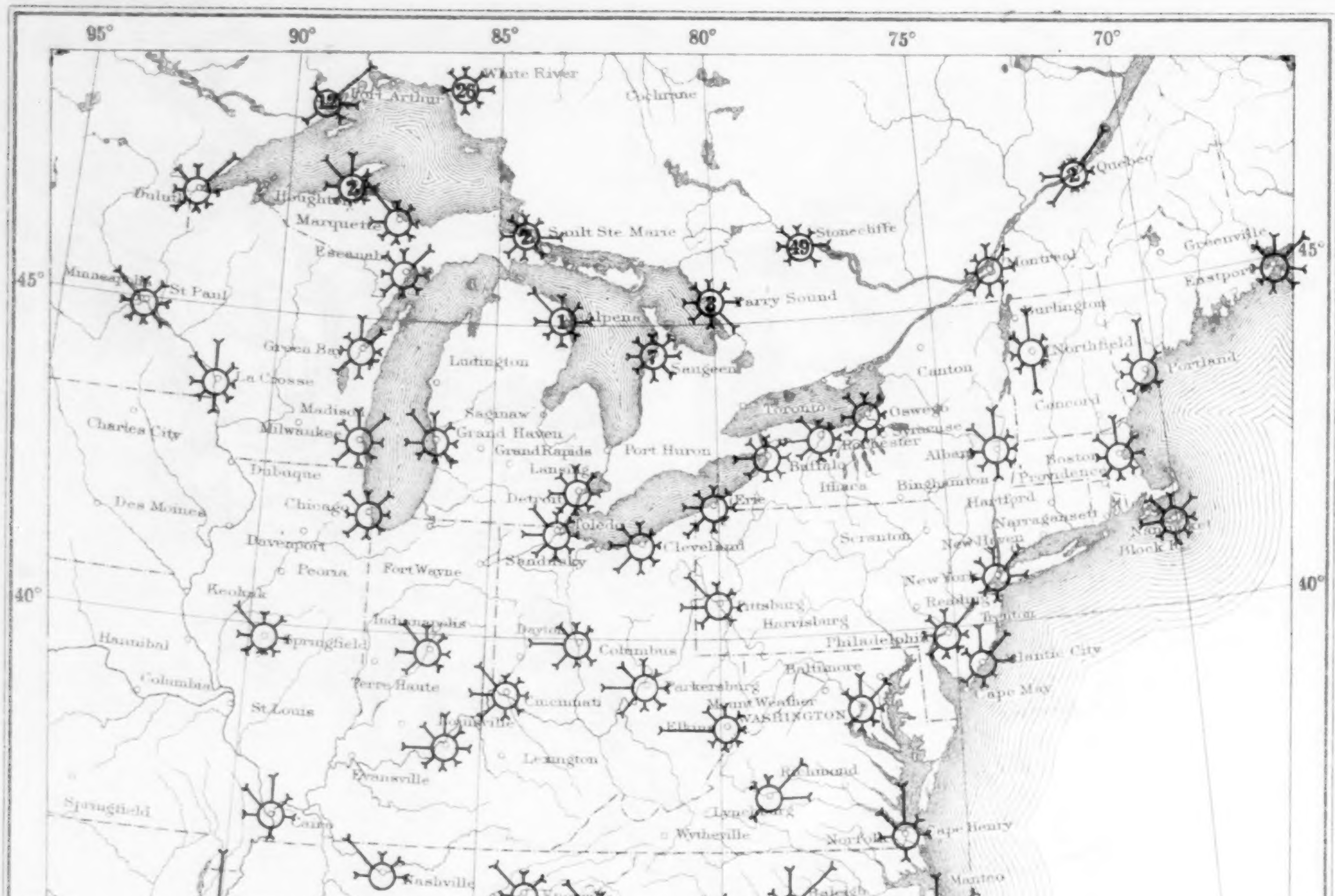


C. F. B. 5.—Average December snowfall (inches) over the eastern United States.



C. F. B. 6.—Snow-bearing winds in January over the eastern United States.

C. F. B. 7.—Average January snowfall (inches) over the eastern United States.

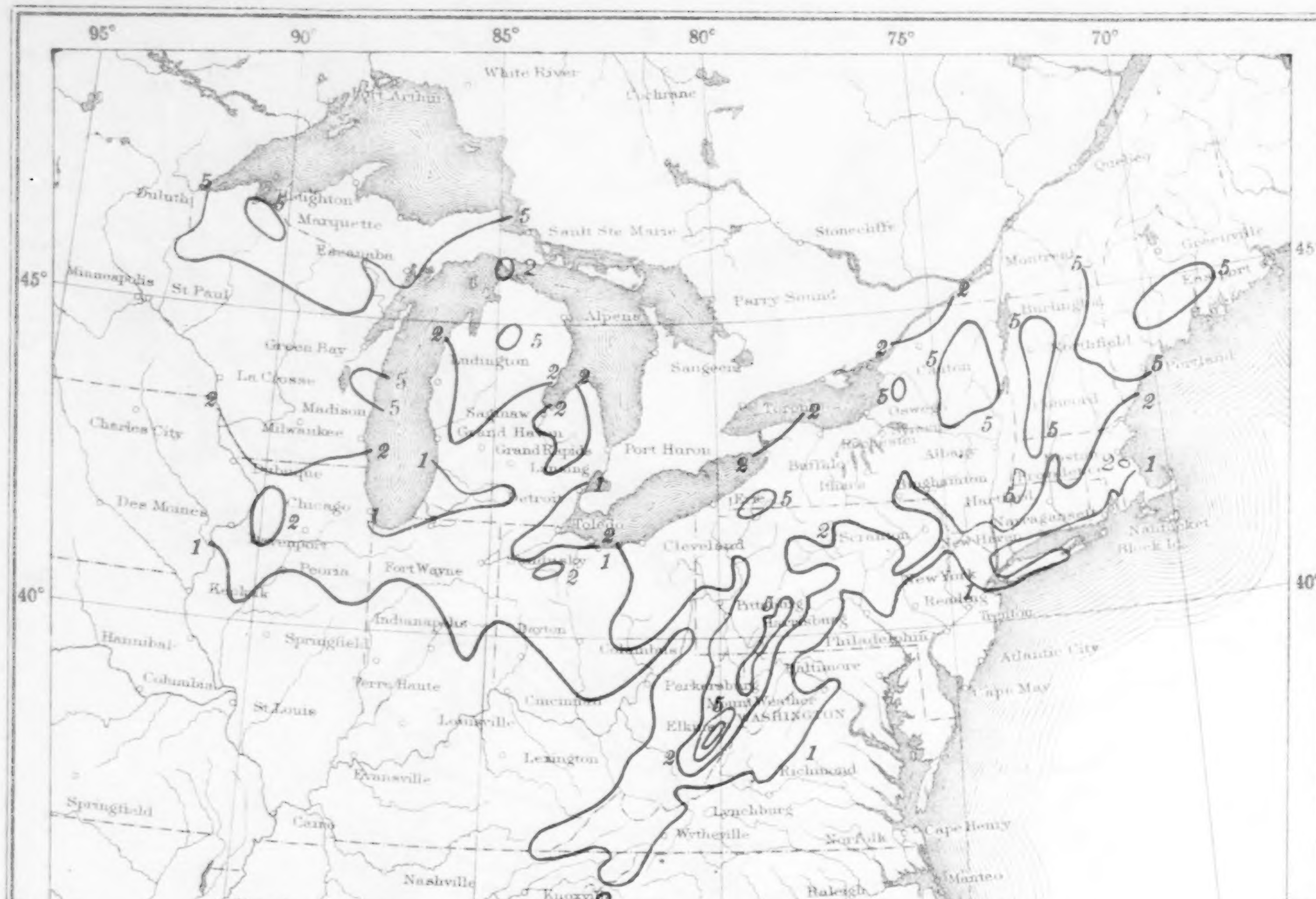


C. F. B. 8.—Snow-bearing winds in February over the eastern United States.

C. F. B. 9.—Average February snowfall (inches) over the eastern United States.

C. F. B. 10.—Snow-bearing winds in March over the eastern United States.

C. F. B. 11.—Average March snowfall (inches) over the eastern United States.



C. F. B. 12.—Average April snowfall (inches) over the eastern United States.

C. F. B. 13.—Average May snowfall (inches) over the eastern United States.

C. F. B. 14.—Average annual number of snowfall (inches) days in the eastern United States.

C. F. B. 15.—Average annual snowfall (inches) over the eastern United States (1895–1913).